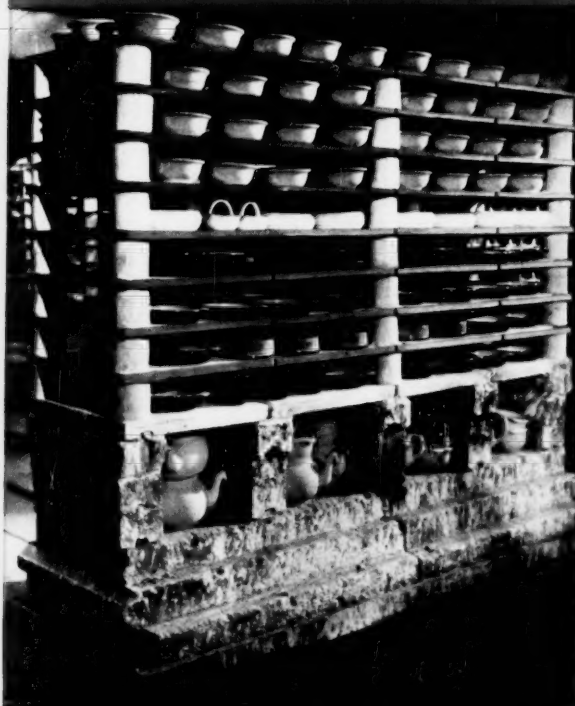


CERAMICS

MAY
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o. 39 Vol. IV



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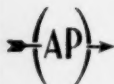
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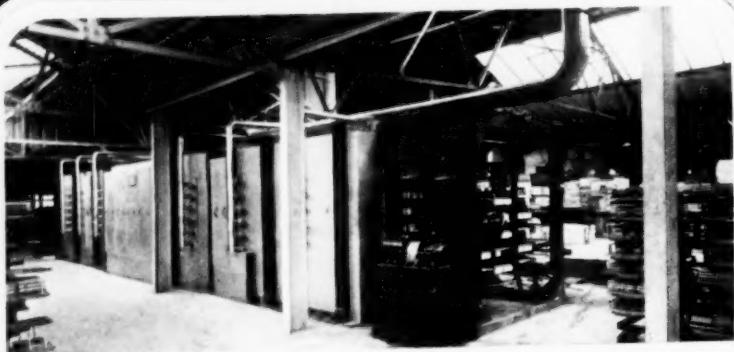


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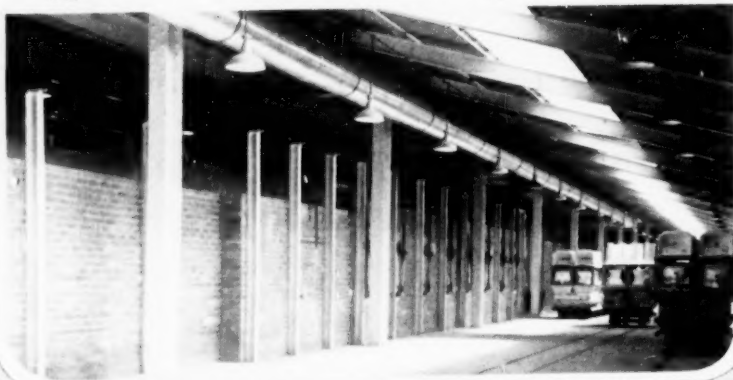


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MAY, 1952

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Ceramics



VOL. IV

MAY, 1952

NO. 39

COMMENT

COINCIDENT with the slight aggravation which has inundated the Potteries on the question of gas tariffs comes news of the recent Industrial Gas Conference in Birmingham in which the gas industry has set out to describe the part it has played towards the national economy.

Although there are only 114,000 industrial consumers of gas, between them they use some 25 per cent. of the gas made in Britain. In the West Midlands the figure is 45 per cent. and in the East Midlands 43 per cent. At least those are the figures given by Colonel Harold C. Smith, chairman of the Gas Council.

In Birmingham a real effort was being made to try and produce a better service to the industrial consumer from the gas industry itself, which through no fault of its own has found itself an unwilling protagonist in the political arena. Domestic gas and industrial gas—the latter with its continuous load, and as was said by Mr. John Walker, director of the Morgan Crucible Co. Ltd., "A spreader of on-costs"; and the former selling in penny packets at relatively high cost per therm per consumer.

Instead of resolving itself as a commercial proposition gas has unfortunately become a political one. Every consumer carries one vote if he or she is over 21, and it appears there are only a few hundred thousand potential votes on the industrial side! That is the problem and one cannot blame altogether the gas technologists for a state of society which is forced on them by democracy!

Diverging, from gas to electricity, Birlec Ltd., has just celebrated the twenty-fifth anniversary of life and it seems odd that it has only lived in one generation! Most of us remember the pioneering efforts of the late A. Glynne Lobley who 25 years ago had the idea of continuous furnaces. The activities of the company in the pottery field are exceedingly well known. Their contribution towards the manufacture of nickel alloy belting has in itself been a worthwhile contribution to pottery production, and what is more, Birlec Ltd., have themselves devised a technique for belt manufacture which has enabled them to produce a better and cheaper belt than by the orthodox methods once employed by the experts.

Yet turning from electricity back again to gas and in view of the "feelings" on this subject among the potters the paper by Mr. J. Walker, director of the Morgan Crucible Co. Ltd., is being reproduced in full because he appreciates the problems which confront the gas industry—and their potential contribution to the national economy—and yet in between the lines he tells the story of how something which is good for everyone on a long-term basis is to some extent being hamstrung by something which is bad and all in the interests—yes, you have guessed right—the politicians!

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POTTERS COMPLAIN AGAIN

by ARGUS

SOME time ago the North Staffordshire Chamber of Commerce complained to the National Coal Board that the importation of coal from other areas is costing the pottery industry an extra £30,000 per annum, and on April 28th a deputation from the Chamber of Commerce met the members of the West Midlands Divisional Coal Board. The deputation stressed that gas coal was being imported into the area from the North-East at a cost of £30,000 per annum, whilst coal from North Staffordshire was being sent to other areas. The Board stated that the allocation of gas coal was on a national basis.

Joint Statement

After the meeting a joint statement was issued which was as follows:

Representatives of the North Staffordshire Chamber of Commerce and the West Midlands Divisional Coal Board met today to discuss points affecting coal supplies in the North Staffordshire Area.

The subjects discussed were: (1) The Coal Board's intention to shortly create a Divisional selling organisation; (2) The supply of gas coal from the North-East Division into Stoke-on-Trent.

On the first subject, the Divisional Board gave the Chamber an assurance that whatever form the Divisional selling organisation takes, it is the intention of the Board to maintain in North Staffordshire adequate arrangements for local contact with consumers and sales service from the existing Sales Office at Stoke-on-Trent.

On the second subject, the Chamber quoted figures to show that the supply of coal from the North-East Division increased the price of gas by 29d. per therm, which, in terms

of consumption by the pottery industry, accounted for approximately £30,000 per annum.

Coal Allocation

In reply, the Board explained that the allocation of gas fuel is a national one and is fully discussed between the Ministry of Fuel and Power, the National Gas Council, and the National Coal Board, and the resulting agreed programme has to be operated by the Divisions.

The shortage of coal can only be resolved by a substantial increase in overall output.

In this, North Staffordshire collieries have a big part to play with their large gas coal reserves, still waiting to be mined, but it must look for major assistance through increased manpower.

Experienced miners from other parts of the country can be found employment in North Staffordshire as soon as houses can be provided for them and their families. It is hoped that the newly-formed Coal Industry Housing Association, acting in conjunction with local authorities, will go a long way to resolve the man-power shortage problem.

It was pointed out, however, by the secretary of the North Staffordshire Chamber of Commerce that the issue of a joint statement did not mean acceptance of the Coal Board's explanations. The secretary added that the volume of supplies from the North-East has increased substantially over the last three years, amounting to 65,069 tons, or about 25.2 per cent. of the total intake. He continued that the difference in price between this coal and that which is mined locally is about 12s. 5d. per ton, which is accounted for by the cost of transport. There prevailed the anomaly that

CERAMICS

North Staffordshire gas coal was simultaneously leaving for other areas.

Essential to Reduce Prices

Mr. Alec Maddock, chairman of the Gas Committee of the British Pottery Manufacturers' Federation, said that the pre-war industry used a million tons of coal, and now, largely through the introduction of continuous tunnel firing it was only using 400,000 tons. The questions were, what had happened to the 600,000 tons of solid fuel saved, and why should it be necessary to import gas coal from the North-East? He continued by saying that it was most essential to get pottery prices down, due to world competition. A reduction in the price of gas for the firing of pottery in the light of the above figures would be a very helpful move.

This is a most dismal story! Readers will recall that as far back as September, 1951, it was reported in *Ceramics* of the application made to the West Midlands Gas Consultative Council by a deputation from the British Pottery Manufacturers' Federation after the Gas Board had declined to see the deputation.

Special Tariff

At that date the deputation, consisting of Mr. Maddock (John Maddock and Son, Burslem), Mr. James Meakin (J. and G. Meakin, Hanley), Mr. John Plant (R. H. and S. L. Plant Ltd., Loughton), Mr. Ralph Halkett (Gas Consultant to the British P.M.F.), and Mr. S. H. Jerrett (Deputy-Chairman of British P.M.F.), pointed out the intense competition from abroad which pottery was facing, (and which has since been further intensified.) They made a special plea for a preferential tariff—it was pointed out that the potters consumed gas continuously, and that they had been encouraged to change from solid fuel to gas in their firing schedules. The Consultative Council concluded by saying that they would send a memorandum to the West Midlands Gas Board "asking them to give it their careful consideration in computing their tariffs."

The story can be picked up again on page 475 of the November issue of *Ceramics*. There one reads that the West Midlands Gas Board regretted

their increased tariffs, but pointed out that coal prices from the National Coal Board had risen considerably. They stated that fuel was being delivered from the North-East to North Staffordshire at an increased price of 11s. 6d. per ton to cover transport costs, but the potters made little headway!

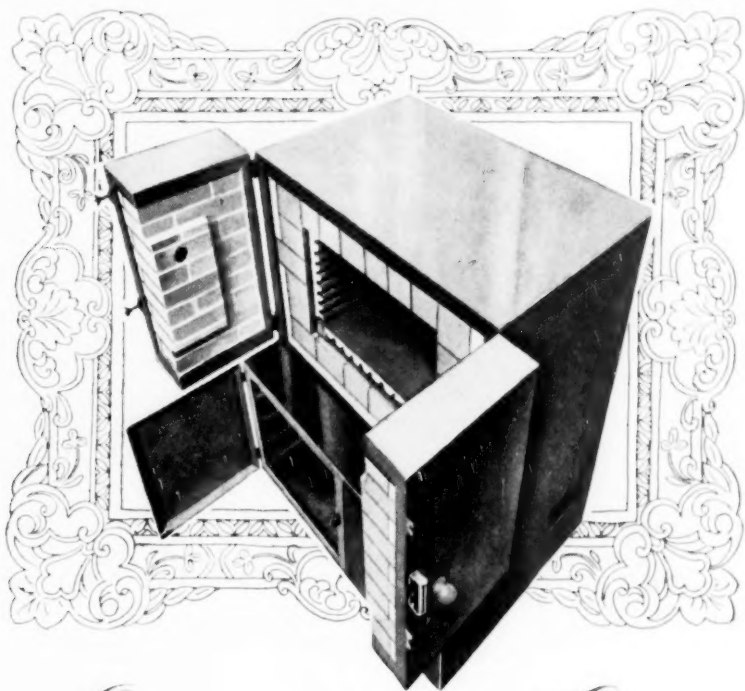
And now come the overtures from the North Staffordshire Chamber of Commerce!

No Redress

Undoubtedly, here is an instance where the plan on paper relating to Consultative Councils falls down completely. The consumer seems to have no redress whatsoever. The Gas Act and the Coal Act only converge upon one another through the Minister of Fuel and Power, who has sole overriding authority to appoint members of either board or of the Consultative Councils. The Acts have led to buck-passing on the highest plane for the customer complains about his gas bill, the Gas Board complain about the cost of its coal—the only satisfaction that is obtained is that gas coal is allocated by the Gas Board on a national basis. Obviously, only the Minister can intervene, but when the investigation began it was a Labour Minister, and now it is a Conservative Minister, so that there is an opportunity for buck-passing even on a higher plane still.

Surely this is one instance where it will be realised that the operation of such Acts as the Gas and Coal Acts, although theoretically designed to help the customer by encouraging the fuel industry, in effect puts him in a frustrating position, the like of which he has never previously suffered.

Record Brick Output. Scottish brick production reached a record output of 61,620,000 in March, 1952, according to Ministry of Works figures just issued. This compares with 54,596,000 in March, 1951. The March, 1952, figure was achieved over 231 working days giving an average of 2,622,000 bricks per day. The record for the first quarter of 1952 is equally impressive at 169,325,000, which is 12 per cent. better than 1951 and 32 per cent. better than 1950.



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M-W.117

Sillimanite Refractories

by

W. L. GERMAN, M.Sc., Ph.D., F.R.I.C.

(Specially Contributed)

SILLIMANITE, $AlO_3 \cdot SiO_2$, is a naturally occurring mineral, but the name is often used indiscriminately to describe all minerals of this formula, namely kyanite, sillimanite, and andalusite, and "sillimanite" refractories may have been made from any one of them. There are differences in the physical properties of the minerals which serve to identify them. Andalusite, which occurs in North and South America, France, Russia, Germany, Spain, and Australia, forms orthorhombic crystals of specific gravity 3.16, and its hardness on Moh's Scale is 7.0-7.5. With kyanite, of which there are important deposits in India, Africa, and America, the crystal form is triclinic with a specific gravity of 3.60. Sillimanite is also orthorhombic, and its specific gravity is 3.23.

	Crystal form	Spec. gravity	Hardness
Sillimanite	orthorhombic	3.23	6-7
Kyanite	triclinic	3.60	4-7
Andalusite	orthorhombic	3.16	7-7.6

Effect of Heat on Andalusite and Kyanite

It had been known for a long time that andalusite and kyanite change on heating and J. W. Greig¹ gives the following review of earlier work on this.

According to this author, kyanite was first described by de Saussure in his book "Voyages dans les Alpes" published in 1796. He noted that the transparent mineral became opaque and was easily powdered after heating. A similar change with andalusite was noted by Haüy.² W. Vernadsky³ showed that the change described by de Saussure took place rapidly in the temperature range

1,320-1,380° C., and that further heating had little effect. He concluded that kyanite and andalusite changed to sillimanite on heating. E. H. M. Beekman⁴ measured the refractive index of the product formed by heating kyanite, and concluded that it could not be sillimanite.

E. S. Shepherd, G. A. Rankin, and F. E. Wright⁵ concluded that andalusite changed slowly to sillimanite at high temperatures. Kyanite changed more rapidly. They were unable to identify the product definitely, but concluded that it was probably sillimanite. It is not difficult to see therefore, why refractories derived from andalusite and kyanite came to be referred to as "sillimanite."

Only Stable Compound at High Temperatures

N. L. Bowen and J. W. Greig⁶ studied the equilibrium between alumina and silica and showed that at high temperature the only stable compound is $3Al_2O_3 \cdot 2SiO_2$, which was called mullite. In optical and crystallographic properties it resembles sillimanite, and this, no doubt, explains the conclusions drawn by earlier investigators.

Sillimanite itself begins to decompose above 1,545° C. into mullite and silica. The crystals formed in ceramic ware, and regarded hitherto as sillimanite, are in fact mullite. This was confirmed by T. S. Curtis.⁷ L. Navias and N. P. Davey⁸ have shown that while the X-ray diffraction patterns of sillimanite and mullite resemble each other, there are important differences in certain lines which are sufficient to identify and differentiate the compounds.

They confirmed that the crystals developed in high calcined china and

ball clays are mullite and not sillimanite.

Sillimanite Refractories owe Desirable Properties to Mullite

As mullite is a very refractory material, decomposing at $1,810^{\circ}\text{C}$. into corundum and molten silica, the so-called sillimanite minerals are all calcined before use to form mullite. It is this substance which confers refractoriness on the sillimanite refractories. Mullite crystallises as interlocking needles, which give mechanical strength when properly developed. The calcination also takes care of volume changes, which might otherwise prove troublesome in service. Kyanite decomposes at about $1,300^{\circ}\text{C}$. with an increase in volume of approximately 10 per cent., andalusite at about $1,350^{\circ}\text{C}$. with little volume change, and sillimanite is not changed till about $1,545^{\circ}\text{C}$. J. W. Greig¹ has shown that there is no definite transformation temperature. The changes with kyanite and andalusite are accompanied by absorption of heat. The silica formed with the mullite is probably cristobalite.

While natural deposits of kyanite, etc., form the cheapest method of

preparing sillimanite refractories, it is interesting to consider syntheses which have been proposed from time to time.

Thus A. Malinovsky¹⁰ described a process in which aluminous materials, such as clays, were smelted with a suitable reducing agent, such as coke, in the presence of iron oxide as a catalyst. Aluminium carbide was formed as an intermediate product and subsequently decomposed. O. Rebuffat¹¹ claimed that a pure product is more easily obtained by mixing kaolinite and hydrated alumina by a wet method, and then slowly heating to $1,400^{\circ}\text{C}$. When wet the mixture may be moulded or mixed with grog. The author stated that the product was a mixture of crystalline and amorphous sillimanite, and soaking at $1,400^{\circ}\text{C}$. or higher reduced the amount of the latter.

Artificial Sillimanite in Germany

During the last war, when supplies of Indian kyanite were cut off, artificial sillimanite was made on a commercial scale in Germany.¹² The cost was about three times that of the natural product, and while the properties of some refractories made



(Courtesy, P. B. Sillimanite Ltd.)

Calcined rock ready to be ground and graded

CERAMICS

from it were comparable with those made from the natural material, there was a higher shrinkage. The raw materials were kaolin, aluminium hydroxide, fused alumina, and small amounts of feldspar. The aluminium hydroxide was ground in cylinders lined with sillimanite till the particles would pass through a sieve containing

some bonding material must be used. The cheapest is clay, but this lowers the refractoriness.

This has been demonstrated by the late Dr. W. J. Rees¹ who investigated the properties of Indian kyanite, calcined to 1,500° C., and mixed with different amounts of clays. An extract of his results is given below:

Bond	Percentage linear Shrinkage (Cone 18)	Refractoriness (Seeger Cone)	Refractoriness under load 50 lb. sq. in. (Seeger Cone)
5 per cent. Dextrin	0.8	38	—
21 per cent. Shellac	0.75	38	—
5 per cent. Ball clay	1.2	38	33
7.5 per cent. Ball clay	2.0	37	31
10.0 per cent. Ball clay	3.0	37	31
15.0 per cent. Ball clay	3.6	36	28
20 per cent. Ball clay	4.2	36	—
30.0 per cent. Ball clay	4.5	36	—
40.0 per cent. Ball clay	5.0	35-36	—
50.0 per cent. Ball clay	7.0	35	—
15.0 per cent. Aluminous fireclay	2.1	37	—
20.0 per cent. Aluminous fireclay	2.4	37	26
25 per cent. Aluminous fireclay	2.5	36	—

10,000 meshes to the square centimetre. The alumina, clay, and feldspar were dry mixed for 5 min., and then the aluminium hydroxide slip was added and the mixing continued for a total mixing time of 20 min. A typical formula is given as:

Clay	...	310
Alum. hydroxide	...	140
Fused alumina	...	50
Feldspar	...	15

The finished mixing had approximately 25 per cent. of water, and was extruded, and cut into pieces about the size of a brick. These were calcined after drying. The firing occupied four-and-a-half to five days in a tunnel oven. This included 24 hours soaking at the peak temperature of 1,600° C. This material was then crushed and graded, and mixed with 5-10 per cent. of a plastic clay as bond, before shaping and refiring. H. Wilson, C. E. Sims, and F. W. Schroeder² prepared an artificial sillimanite by fusing mixtures of quartz, china clay, fireclay, and alumina in an electric furnace.

The sillimanite minerals have no plasticity, and for manufacturing purposes, as has already been indicated,

Similar results were obtained with a siliceous fireclay bond.

The composition of the mix can therefore be adjusted to meet the service requirement, since there is no point in using more of an expensive material like sillimanite than is necessary to give the refractoriness required.

Manufacture of Sillimanite Refractories

In manufacture the raw material is commonly calcined to 1,500-1,600° C. for a day. This brings about mullite formation, and also makes the material easier to crush. After crushing the material is graded. Where a finer grog is required it may be necessary to grind in a cylinder. After mixing with the refractory clay and water, shaping is carried out by the standard methods such as casting, jollying, extrusion, and pressing. For comparatively low grade material the fire clay addition may vary from 34-60 per cent., and the ware is fired at 1,500-1,600° C. Super grade products have only about 5 per cent. of clay added and are fired to a higher temperature (cf., E. Rosenthal¹¹).

The properties of refractories containing sillimanite have been the

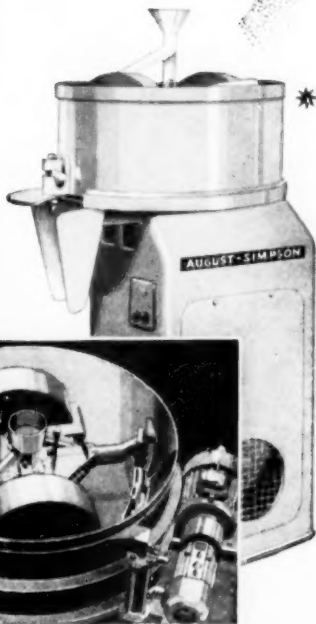
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Inset picture shows the No. 2 size with mullers (adjustable for height from bottom of pan) and the plows which turn over the material and direct it in front of the mullers. The Hood (not shown) supplied as standard for all ceramic installations.

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Courtesy, P. B. Sillimanite Ltd.

Tunnel kiln used for burning kyanite in the production of P.B. Sillimanite.
Note arches of sillimanite brick

subject of a number of investigations.

H. S. Houldsworth¹⁰ studied the properties of some clay-sillimanite mixtures. He showed that additions of sillimanite to clay lowered the drying and firing shrinkages, and increased the porosity. In addition, more than 50 per cent. increased the refractoriness. A mixture of 95 per cent. of sillimanite and 5 per cent. of clay showed a regular expansion over the range 15-1,000° C., and this was apparently not affected by the firing treatment up to Cone 18. The rapid expansion shown by fireclay in the temperature ranges 100-200° C. and 500-600° C. were reduced by the addition of sillimanite. A mixture with 10 per cent. ball clay showed marked resistance to attack by soda lime glasses and basic slag. Mixtures with less than 50 per cent. of the refractory were little more resistant than the fireclay alone.

Other aspects of the behaviour of these refractories when used in tunnel kilns are given by F. H. Riddle and R. Twells.¹¹ They used refractories derived from andalusite, and showed

that the best mixtures melted above Orton Cone 40 (1,885° C.), which is similar to the value given by W. J. Rees (loc. cit.) for kyanite, bonded with organic materials. Load-bearing properties were tested at high temperatures using a 9 in. brick, and also by bars supported at the ends and carrying loads.

The brick showed no deformation under a load of 50 lb./sq. in. at 1,525° C. The transverse testing bars were 12 in. long, 2 in. wide, and $\frac{1}{2}$ in. thick. They were placed on supports 11 in. apart. A load of 45 lb. gave $\frac{1}{8}$ in. sag at Cone 16 $\frac{1}{2}$, and $\frac{1}{4}$ in. with a $\frac{1}{2}$ lb. load at Cone 34 down. Stability tests showed the refractories to be relatively constant in volume, and they improved with use. They were unaffected by kiln gases. Saggars used at 0 Cone 12, had a life in excess of 180 cycles, and at Cone 16 $\frac{1}{2}$ the average life was estimated at 1 $\frac{1}{2}$ years, though some were much older and still serviceable. Kiln cars with sillimanite superstructures had been in service at Cone 16 $\frac{1}{2}$ for 5 years, as against 3-4 months with fireclay. The

material was also satisfactory for the heating zone of Dressler kilns.

R. Twells¹² has confirmed the usefulness of sillimanite refractories in kilns, especially when volume stability and resistance to thermal shock are required.

The list of uses of sillimanite at present is formidable, and one supplier advertises the following applications: In furnaces it is used for combustion chambers, recuperator tubes, and for any parts that have to support heavy loads at high temperatures, or are subject to thermal shock. It can be used as a lining for frit kilns, where its resistance to attack by molten glassy material is useful. For the same reason it is used in the pot and tank furnaces where glass is melted in those parts which are normally subjected to heavy corrosion. It is also applied to making the jets in glass wool furnaces, and as an ingredient in cements used for patching furnaces. In the cement industry it is used for lining the burning zone of the rotary clinker kilns.

In the manufacture of pottery and

clay wares it is widely utilised in the firing zones of continuous tunnel ovens, and also for the manufacture of kiln bats and furniture. Its high electrical resistance at elevated temperatures is useful in the construction of electrically-fired kilns, in which sillimanite formers or blocks are used to support the metallic resistors.

The material is also used in the electrical trade for formers for wire-wound electric fires, for powder-filled tubular immersion heaters, and for cement-filled hot plates. It can be added to ceramic bodies to reduce shrinkage and thermal expansion, and to improve refractoriness, strength, and electrical resistance.

Its exceptional properties also make it an important material of construction in the chemical industry, such as for certain parts of zinc and gold smelting furnaces, and it is also used to resist the action of alkali in furnaces used for the production of sodium silicate and sulphide.

F. H. Clews, H. E. Dobbin, and A. T. Green¹³ have described experiments to produce sillimanite products



(Courtesy, P. B. Sillimanite Ltd.)

Deck of kiln car being repaired with sillimanite bricks and bonding

CERAMICS

with high porosity. The aim was to obtain a material of low heat capacity and conductivity combined with stability under load. Addition of 25-30 per cent. of anthracite to a mixture of sillimanite bonded with 7 per cent. of bentonite, and subsequent firing at temperatures over 1,500° C. gave a product with 60-70 per cent. porosity and satisfactory strength. Slightly better results were obtained by frothing the mixture with acid and aluminium powder, but it was difficult to control the operation.

Additions of paper pulp followed by firing at 1,400° C. were also tried, and gave materials with 60-65 per cent. porosity and a refractoriness under load of 1,350° C. High shrinkage and cracking were drawbacks. These were overcome by the use of a porous sillimanite grog from the earlier experiments. This increased the porosity, but there was less stability under load.

A. R. Chadeyron and W. J. Rees²⁰ have pointed out that sillimanite refractories are only used to a limited extent in the steel industry because of their lower resistance to ferruginous slags than basic refractories of comparable price. They carried out experiments to see whether the resistance could be improved by additions of chromium oxide and chrome ore. Addition of up to 15 per cent. of chrome oxide markedly increased the resistance to acid and basic open hearth slags, and to hammer scale. The refractoriness under load was slightly lowered by these additions, and when the amount of chromium oxide was further increased the lowering was appreciable. Similar results were obtained with chrome ore, but the resistance to slag attack was less marked. All the mixtures examined showed high resistance to spalling. These examples illustrate how research may extend the usefulness of sillimanite refractories.

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PACKING EXPORT GOODS

MORE than 18,000 tons of British wood wool were used in the packing of British export goods during the past year, said Mr. E. W. Baldwin, chairman of the Association of British Wood Wool Manufacturers, at the Tenth Annual Meeting of the Association held in London recently.

He said that this represented 75 per cent. of the wood wool produced by members and that in some cases export goods up to £100,000 in value have been packed in 1 ton of wood wool.

Mr. Baldwin went on to say that wood wool could be produced in a variety of grades to meet all packing needs and as its use, unlike substitutes, was freely permitted by the U.S.A. authorities, it had a special attraction for dollar exporters.

The Association of British Wood Wool Manufacturers represents manufacturers of more than 95 per cent. of wood wool produced in this country.

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TUNNEL KILN TESTING

WHEN the early tunnel kilns were built, wood and coal were the principal fuels, and it was therefore necessary to operate them with the fire zone under draught. These kilns were not very successful. There was considerable channelling of hot and cold gases in the fire and preheat zones, and because of the high draught there was considerable leakage of cold air from under the cars and around the doors of the kiln.

Only after kiln designers turned to gas and oil fuel and found that the fire zone could be maintained under a slight pressure was a real measure of success reached. With the fire zone under pressure, it was necessary to raise the pressure in the cooling zone in order to maintain the flow of gases in the right direction. The exit end of the kiln was enclosed and a fan added to force air in. To avoid reducing conditions directly in front of the oil or gas burners, it was found necessary to supply nearly all the air for combustion through or around the burners.

Since less secondary air was needed in the fire zone, it was necessary to provide means of maintaining the flow of cooling air. This was done by providing relief ports where the excess from the cooling zone could be removed. This clean hot air was then used in waste heat driers.

It was soon recognised that there was a tendency for the hot gases to stay near the top of the tunnel, particularly in the preheat zone. To overcome this tendency and to provide a means of controlling the rate of pre-

heat, some kiln designers provided exhaust ports along a hollow wall, which extended about one-third the length of the preheat zone. The ports were at car deck level, to pull the heat from the top of the tunnel down through the setting and out the stack. They were also adjustable in order to give a means of controlling the temperature distribution curve in the preheat zone.

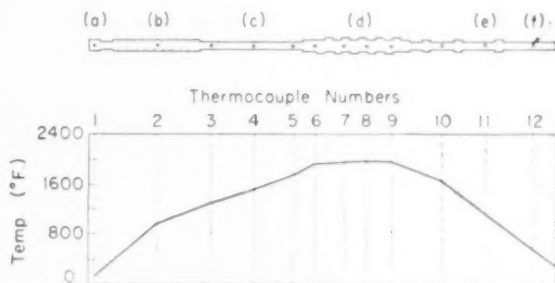
Finally, a means of determining temperatures in the kiln was provided. A string of thermocouples was installed in the crown of the kilns from entrance to exit. In many kilns, a thermocouple was also placed in each firebox to help keep the fire zone even.

In Fig. 1 are shown from left to right:

- The vestibule, a means of introducing cars to the kiln without having the end of the kiln open to room pressure at any time.
- Exhaust fan, stack, hollow wall, and exhaust ports for control of the rate of preheat.
- Preheat zone where the ware is heated as the combustion gases are cooled.
- Fireboxes in the fire zone where the fuel is added and the maximum temperature is reached.
- Cooling zone with relief ports where much of the air added at the end of the kiln for cooling the ware is allowed to escape from the tunnel. This hot air is then used in waste heat driers.

An extract from an article, "Tunnel Kiln Testing," by Morris P. Hall, *Amer. Ceramic Society Bulletin*, March, 1952, 85-88.

Fig. 1. The outline and firing curve for a typical tunnel kiln firing heavy clay products: (a) entrance (b) exhaust fan, stack, hollow wall, and exhaust ports (c) preheat zone (d) fire zone (e) cooling zone, and (f) thermocouples spaced along the crown of the kiln



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(f) Thermocouples spaced along the crown of the kiln.

The lower portion of Fig. 1 is a typical firing curve as taken from the thermocouples. Couple 1 will depend more or less on the temperature of the drier or preheater. This kiln was operating without a preheater, and the first couple was only 120° F. Couples 2 and 3 can be regulated to a certain extent by changing the size and distribution of the exhaust ports. In this case the temperature was 970° F. on 2 and 1,280° F. on 3. Couples 4 and 5, here at 1,500° F. and 1,730° F., can be controlled somewhat by regulating the draft. Couples 6, 7, 8, and 9, at 1,920°, 1,940°, 1,960° and 1,950° F. in this particular kiln, can be controlled by adjustments to the burners in the fire zone. Leaving the fire zone, the temperature dropped in a fairly straight line to 1,640°, 1,120°, and 520° F. Projecting this out to the end of the kiln, the cars would leave at about 300° F.

But is this a true curve for the ware going through the tunnel kiln? Does the ware follow the same curve as the temperatures indicated by the crown thermocouples? What is the temperature in the bottom of the setting when the crown temperature is between 1,000° F. and 1,200° F?

It was decided to find the answers to these questions by running traveling thermocouple tests on a number of kilns firing a variety of products. Thermocouples were placed directly in the setting, one near the top and one just above the car deck, and extended through the deck and fastened to compensating lead wire which dragged under the cars.

In Fig. 2 are shown the results of the traveling thermocouple test on the same kiln as in Fig. 1. The couple in the top of the setting (a) started up

fairly rapidly until it reached 900° F., then flattened out and took a fairly even course from there to the fire zone. The bottom temperature (b), however, stayed below 100° F. for six car lengths. At couple two the crown is 980° F., the top is 880° F., and the bottom 200° F., a difference of nearly 15° F. per in. Through the last part of the exhaust zone the bottom temperature fluctuates as the hot gases are pulled down through the setting and out the exhaust ports. The bottom ends up about 300° F. below the top as they leave the exhaust zone, and this is slowly reduced until, at the first firebox, the difference is only 50° F. Through the fire zone the bottom temperature exceeds the top slightly directly in front of the fireboxes until box 8 is reached where the temperature shoots up about 60° F., positive proof that 8 was out of balance with the rest of the fire zone. In the cooling zone the bottom temperature falls off a little faster than the crown temperature, but is a fairly even curve to the end of the kiln. The top, however, stays well above the crown temperature, and is still above 800° F. when the car nears the end of the tunnel. At this point it is hit by air from the cooling fan and drops like a shot to 350° F.

This was what we were looking for. This kiln was being operated at that time on a very slow schedule of ten cars, a total of 120 hours. The face bricks in the bottom of the setting were fine, but the dense burning floor tiles used for top setting, even at this slow schedule, were cool-cracking. Thus it was found that while the crown couples indicated a smooth cooling curve, the dense top setting was in reality being subjected to a blast of cold air just at a critical point in the cooling curve.

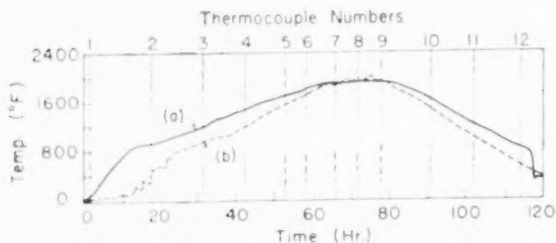


Fig. 2. Results of the traveling thermocouple test for the same kiln as shown in Fig. 1: (a) top of setting (b) bottom of setting



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FELSPARS IN CERAMIC BODIES*

by

I. C. McDOWALL and W. VOSE

THE range of ceramic whiteware compositions has been extensively widened in the last 20 years and now includes products with exceptional physical strength, resistance to thermal spalling, resistance to dielectric breakdown or other properties.

The economic and technical difficulties of their production and utilisation has prevented any comparatively large replacement of the traditional felspar-clay-quartz type bodies in the fields of domestic pottery and industrial porcelain.

Procedure

Felspars generally occur associated with other minerals—mainly quartz. For various reasons these other minerals may be removed, e.g., iron bearing minerals because of colour, quartz to increase the felspar content of the material. The felspars are then dry or wet ground to predetermined particle sizes and mixed with clays and quartz.

The felspar in water may decompose and give up alkalis to the suspending electrolyte so modifying the physico-chemical relationships. The felspar is bonded into this heterogeneous system and the particle boundaries contact air, clay and quartz particles.

As firing proceeds, the differential thermal expansion between the crystalline felspars and other materials may cause some movement of this now rigid structure.

At a certain temperature the felspars fuse, expand, wet the other particles and as the temperature increases, the viscosity decreases. Surface wetting by the liquid phase develops surface tension forces which are said to draw the particles of refractory aggregate together. The air capillaries are closed or filled in and at some stage the temperature increase ceases and cooling begins. This explanation generally used and accepted needs a critical examination. (Note. The sintering of the particles or solid to solid reactions are excluded from these considerations.)

The glass and heterogeneous crystal phases cool together. The glass and crystal phases have different thermal contraction properties which cause strains when the glassy phase has been cooled to a non-liquid state (non-liquid from this physical aspect).

The glass will now be of a different composition from the original felspar glass because of differential solution of the refractory crystal constituents, e.g., quartz, mullite.

The crystalline refractory constituents may or may not have changed. New crystalline compounds may have been formed.

The paper continues by giving details on the properties of felspars, including relevant phase diagrams.

The Melting of Felspars

The value of felspars in ceramics is due to its fusion alone and in association with the other components of the compositions whereby it bonds them together. A practice arose of testing the suitability of felspars for this purpose by grinding the material, making cones or similar shapes, and

* An extract from Technical Report No. 6 of the New Zealand Pottery and Ceramic Research Association (Inc.) entitled, "Felspars and their use in Ceramic Bodies of the type Felspar Clay-Quartz" published in May 1960. Copies of the full report are available from the Association at 111 Sydney Street, Wellington, New Zealand.

firing them at predetermined temperatures. From the fusibility, determined by a visual examination of these test pieces, the suitability of the material was determined. A most misleading procedure.

It is clear that the following properties are significant in the melting and plastic deformation of a felspar:

(a) The chemical composition of the felspar—which will determine the equilibrium state when heated to a specified temperature.

(b) The mineralogical composition which determines the initial points from which the system moves towards the equilibrium state.

(c) The particle size of mixed minerals which will determine the rate of movement towards the equilibrium state.

(d) The quantity of crystalline material in a partially fused mass and the size of the crystals.

(e) The viscosity of the glass formed. The viscosity of melted felspar must be of great importance in the vitrification processes. The viscosity and the effect of temperature will be different in the case of a mineral with a definite fusion temperature, e.g., albite compared with one with an incongruent melting point, e.g., orthoclase, where the melt consists of liquid plus solid phase (leucite). The apparent viscosity of a mineral mixture will also be different from that of the minerals in solid solution and especially where one of the minerals is very refractory, e.g., anorthite and albite.

When used in ceramic compositions, the reactions of felspar with the other body components are important and these are considered later. The limited value of the P.C.E. of a felspar alone as a measure of its suitability for ceramic work is obvious.

The "melting point" of felspars has been the subject of a large amount of empirical work.

Geller and Bunting⁷ consider that below 1,000° C. "felspar" acted as an inert aggregate whilst Duderov finds "felspar" not entirely fused after 37 hours firing to 1,300° C.

Details are then given of the viscosity of molten felspar, softening points, and the solubility of quartz and clay in felspars.

Effect of the Type of Felspar Used

Schramm and Hall⁸ estimate the quantity of glass in a true porcelain as about 2½ times the percentage of felspar used. The mineralogical differences in felspars are considered not to be important provided the integrated chemical composition of the components remains the same. This chemical equivalence does not refer to the quartz content, which must be considered as part of the quartz component of the whole body, but only the combined silica. They examined the mixtures of soda and potash felspars and found leucite to be formed even at quite high soda contents. The danger in using the fusibility tests upon felspars from which to anticipate their action in bodies was described. For example:

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P.C.E. values of soda
felspar Cone 5

P.C.E. values of potash
felspar Cone 10

P.C.E. values of a soda/
potash felspar Cone 8

and yet (a) more of the mixed felspar than potash felspar was needed for a comparable porosity in a body, and (b) the difference in vitrification of bodies from individual soda and potash felspars is much less than would be expected.

Geller and Creamer⁷ and Amberg and Gallup⁸ even found that soda felspar tends to be more refractory than potash felspar in bodies, but this does not agree with the further statement by Geller and Creamer that with semi-vitreous bodies (in the absence of auxiliary fluxes such as lime), soda felspar matures ahead of potash felspar.

Popova⁹ needed higher vitrification temperatures with plagioclase than microcline.

Chilcote¹⁰ using microcline, albite and andesine felspars in a standard body found a ternary eutectic at:

microcline 30 per cent.

albite 60 per cent.

andesine 10 per cent.

This body gave higher vitrification as measured by low absorption, higher modulus of rupture and higher translucency.

Overfiring

In a body using a series of felspars, Geller concluded that those bodies with the highest Fe_2O_3 tended most to overfire. Overfiring was less, however, with felspars of higher quartz content. In a series of vitreous bodies one using soda felspar did not overfire as anticipated. The felspars used by Geller varied from high soda to high potash. He found that the fired porosity reached a maximum with felspars intermediate in fineness, K_2O content and quartz content.

Rieke and Mauve¹¹ having determined that the glassy phase of a porcelain body could be represented by felspar 36.8 per cent., quartz 58.8 per cent. and clay substance 4.4 per cent. made some melts. Soda felspar gave the least viscous melts but the rapid softening with increased temperature, characteristic of the pure soda felspar

does not occur. These mixtures did in fact give a viscosity at 1,200° C., thirty times as great as the pure felspar.

Effect of Particle Size of Felspar

It is generally known that replacement by a finer grained felspar lowers the porosity and sintering point of a porcelain or earthenware body. This holds throughout the temperature range.

Geller, Evans and Creamer⁷ examined the fusion of felspar in bodies, the spar having been prepared as all below 10, 20, 35 and 75 microns respectively. The firing shrinkage and degree of vitrification took the anticipated courses. Important observations were made, however, upon sections of fired body.

At 1,150° C. particles of felspar below 10 microns could still be detected in considerable quantities.

At 1,250° C. all felspar grains below 10 microns had disappeared, but particles 10-20 microns could still be observed, the larger particles in fairly sharp outline.

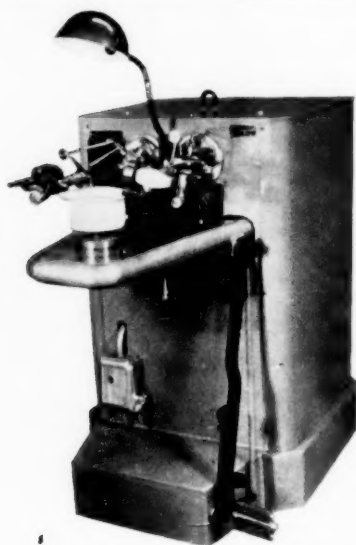
At 1,350° C. all the particles of felspar below 10 micron and nearly all below 20 micron had diffused into the bodies. Larger particles remained, but on fusing had lost their sharp outlines. They were mottled due to mullite crystals.

It is clear, therefore, that the diffusion of fused particles of felspar into a body is a function of the particle size and temperature. With increase in temperature, the limiting particle size increases. The wider significance of these observations is under investigation. The importance of surface area of both the fusible and refractory components upon the rate and degree of interfacial reactions is evident.

As an example of a refractory component Harris¹² observed that the removal of fine flint slowed up the vitrification of a body.

Fusion and Softening of Felspar in the Ceramic Body

In agreement with Geller, Evans and Creamer⁷ above, Kramer¹³ states that only fine felspar particles form the glassy matrix, the large ones retaining their shape, fusing and becoming isotropic. He considers that the



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mullite crystals penetrate these liquid masses.

Norton and Hodgdon¹² were interested in the viscosity of the glass formed in the firing of felspathic bodies and the rate of formation and total quantity of the glass phase. They suggested that an increase of 20-30° C. increases the rate of the vitrification reactions tenfold. Now, since the temperature coefficient of viscosity of typical glasses is not of this order (Table I) they consider that the mechanism of the high temperature reactions is the source of this large temperature coefficient.

TABLE I
TEMPERATURE VISCOSITY OF A TYPICAL GLASS

Temperature °C.	Log. viscosity
1,100	3.5
1,150	3.2
1,200	3.0
1,250	2.8
1,300	2.7

Whilst not describing the nature of these high temperature reactions, they do give an account of an examination

of a series of sections from a sanitary and electrical porcelain body which were found to be similar.

Fired at 1,250° C. for 10 min. to give zero porosity, almost all the felspar has melted. The felspar grains have not diffused into the body but remain as an isotropic mass which retain the outline of the original grains. (No mention is made of the particle sizes.)

With a longer time, i.e., 100 min. at 1,200° C., still giving zero porosity, only the large felspar grains still maintain their original outline, the ground mass becoming more homogeneous.

Norton and Hodgdon now fired for 1,000 min. at 1,175° C. and 10,000 min. at 1,120° C. with similar results. Zero porosity was obtained and pseudomorphs of the large felspar crystals were observed, with needle crystals of mullite embedded therein. They considered that the mullite needles do not penetrate from the ground mass into the felspar crystal outline—or vice versa, but that the mullite crystals are formed in the

CERAMICS

felspar glass. If this is so, some diffusion into the felspar glass must have occurred because no mullite is obtained by heating felspar alone.

Kramer¹² on the contrary states that the mullite crystals "penetrate" the large fused felspar crystals.

Mullite Development

It is quite clear that the nature of the felspar does determine, i.e., degree of mullite formation. Geller¹ found a noticeable influence amongst the wide range of felspars with which he worked although only a little difference in mullite formation between bodies from high albite and high orthoclase felspars. Popova¹³ on replacing microcline by plagioclase found an increase in mullitization of the bodies.

McVay¹, certainly using "coarse" felspar (graded between 20 and 200 mesh) found that crystallisation starts at the boundary of the clay and felspar. The first mullite crystals are orientated nearly normal to the interface. No mullite crystals were formed in the interior of the large crystals, although they were found in the exterior of fused small crystals and not orientated to the surface. Solution of clay would explain this. Thus the two possible causes for mullite formation are:

- (a) direct association of "recomposed clay" to form large crystals, and
- (b) by solution of clay in felspar and subsequent crystallisation.

Felessofov and Stchepetow¹⁴ also find that felspar promotes the growth of mullite needles.

Orthoclase felspar dissolves only 20 per cent. clay before mullite appears, according to Fessler and Naurateil.¹⁵

Norton and Hodgdon¹⁶ have noted that diffusion and reaction processes are highly important in the vitrification of ceramic bodies but that simple solvent action is not enough to explain the phenomena observed.

Translucency as Dependent upon the Felspar

In his work, Geller¹ found the translucency of the bodies to generally increase with the potash content of the felspar. It should be noted, how-

ever, that as the K₂O content of his felspars increases, so does the total alkali content. The real cause may, therefore, be an increase in the total glass content of the body. The same effect, but in less degree, was noted in substituting the felspars in a 50/50 flint/felspar mixture. As we have seen above, the presence of clay increases the solution of quartz in felspar, thus increasing the glass formation. This would account for the difference as it is known that the percentage glass content is an important criterion in the translucency of ceramic bodies.

There is no evidence of the potash felspar glasses having refractive indices widely different from the soda one.

The effect of particle size on translucency is not clear. Felessofov and Stchepetow¹⁴ find that translucency increases with increasing grain size of total non-plastics, quartz and felspar presumably. Semenoff and Avdeef,¹⁷ however, state that transparency increases with finer milling, although they are possibly referring only to the quartz.

Stuckert and Paul¹⁸ obtain maximum transparency with particle size of quartz and felspar of 10-25 microns.

It would be expected that two mechanisms of light transference would operate:

- (a) by passing through contiguous large particles of quartz or fused felspar. In this case the coarser the non-plastics the more translucent, and
- (b) by passing through a body with a high percentage of glassy phase. Here, those factors increasing the percentage of glassy phase will give higher translucency, e.g., high percentage of felspar and finely ground.

Thus the apparent contradictions could be resolved.

The closer the refractive indices of glass and crystalline phases, and the lower the absorption of light of each phase, the more translucent, also.

Specific Gravity as a Measure of Glass Formation

As seen earlier, felspar on fusing passes into a glass of lower density. Chervinskii¹⁹ by measuring the

specific gravity tried to follow the progress of vitrification of a porcelain body. He found a decrease in specific gravity in the region 1,000°-1,100° C. which is greater than that due to fusion of the felspar. Also that that part of the vitrification process accompanied by a considerable lowering of the specific gravity ends at approximately 1,200° C. for porcelain. Only a slight lowering of the specific gravity of the porcelain occurred over the range 1,200-1,300° C. but it is greater in the interval 1,300-1,400° C. when solution of clay and quartz is greater.

Other Characteristics Affected by the Felspar

Coefficient of Expansion

Geller¹ experimented with different felspars, in a vitreous and semi-vitreous body given in Table 2. The thermal expansion was highest with the soda felspars. He concluded, thence, that the best result would be obtained with soda felspar in the body with potash spar in the glaze.

Morey and Bowen² explained the variations in thermal expansion of bodies with firing, thus: higher firing converts more quartz with a high thermal expansion to a glass with a lower thermal expansion.

Geller¹ also found that semi-vitreous bodies which are cooled slowest show the highest average coefficient of expansion.

TABLE 2.
BODIES USED BY GELLER

	<i>Vitreous</i>	<i>Semi-Vitreous</i>
Ball Clay	7.5	15.0
Kaolin	8.0	8.0
China Clay	29.0	29.0
Flint	36	36
Felspar	18	14
Whiting	1.5	—

Mechanical Strength—General

Geller¹ could not relate differences in mechanical strength to the type of felspar and thought that the strength depended more on firing than upon felspar differences.

Kramer¹⁷ states, however, that the glass composition is most important and should be controlled to obtain the optimum physical characteristics.

Felessofov and Stchepetow¹⁸ found the mechanical strength to decrease

slightly with increase in the size of the felspar. Snyder's experiments¹⁹ in the clay-felspar-quartz field determined that at cone 7, the greatest strength is found in the high felspar, low flint area. With increased firing temperatures the area of highest strength tends to move towards the high clay/low felspar composition. The rate of vitrification is most affected by the flint content. The widest firing range occurs in bodies with less than 20 per cent. flint and at the same time a broader range of high strengths occur before the usual drop.

Chipping and impact strength and modulus of elasticity

Little significant difference has been attributed to the type felspar used. Geller¹ found none.

Mica

Mica is generally associated with feldspathic rocks and clays. In clay it is generally very fine in particle size. The difficulty in grinding the mica associated with felspars may lead to coarse mica in the body mixes. The properties of mica are therefore of some importance and the following notes will indicate the part it will be likely to play.

Watts²⁰ has suggested that microscopic mica may exist in felspars and account for the excess alumina usually calculated as kaolin.

Zwetsch showed that mica remains unaltered below 900° C. but at 950° C. decomposition occurs and alumina and leucite are formed.

Geller and Bunting²¹ in their examination of the firing properties of clays and bodies found that mica had a marked effect upon the firing shrinkage of clays.

Pure kaolinite shrunk about 3 per cent. between 500 and 1,000° C. Twenty grm. of mica to 100 grm. of clay turned this into an expansion of 0.26 per cent. They considered that the mica effect is probably a reaction with the clay, as changes caused by it cannot be wholly accounted for by calculations based on thermal expansion measurements or specific gravity changes. No account had been taken, however, of the possible orientation effects of the mica particles during extrusion of the test pieces.

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Muscovite mica has a high expansion of 0.73 per cent. between 20-1000°C. This calculates to a coefficient of 8.3×10^{-5} per °C. Its fusion temperature is 1,400°C.

It is to be expected, therefore, that large mica flakes will cause some movement in the structure of a body.

Geller and Bunting whilst observing such lines of weakness up to 1,000°C. considered that they would heal during the later firing.

Other references to mica flakes as a source of drying cracking and firing cracking suggest that mica in feldspar should be viewed with suspicion and care taken in milling and sieving to prevent coarse flakes from passing into the body.

Conclusion

Our present knowledge of feldspars and reactions in ceramics is of very variable value. Where the materials under examination are in a static or equilibrium state solid progress has been made. For example, the mineralogical information is precise and our analytical and petrological examinations are standard procedures. Similarly, the phase relationship in the respective systems as recently determined are quite clear and give the ceramist an accurate knowledge of the equilibrium conditions within the systems.

However, when we examine our knowledge of the dynamic processes in the ceramic field, we find it bulky but of little fundamental value. The many contradictions are due to the empirical nature and omission in design of the experimental work, the main defections arising from a general disregard of importance of the surface area of the reactants in solid-liquid, solid-solid reactions. Modern techniques have made more direct and fundamental experimental work possible. Some earlier workers have made contributions which indicate the necessity for, and promise of work upon, the dynamics of the reactions between the minerals constituting ceramic bodies.

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John Moncrieff Ltd. The long-established Perth laboratory and art glass-making firm of John Moncrieff Ltd., St. Catherine's Street, Perth has been acquired by David Bennie and Sons Ltd., steel-rollers of Petershill Road, Glasgow. Moncrieff are famed in both technical and art circles for the quality of their workmanship and have maintained at Perth the art of glass making when it tended to decline in other centres. While especially well known on the laboratory side and prominent as suppliers of a wide range of blown and fabricated glass work, Moncrieff also produce some very beautiful marbled art glass which has been bought widely by collectors.

An Introduction to Prestressed Concrete

by

E. L. ROBSON, B.Sc.

(Northern Gas Board)

IN his opening remarks to this paper the author dealt with the basic principles of prestressing concrete, including the earlier methods, as well as the design principles employed. He went on to say:

Advantages

The great advantage of prestressed concrete over reinforced concrete is that the product is entirely free from cracks. While it cannot be used for all purposes to which reinforced concrete has been put, it can be used for the majority of them.

On the other hand, it can be used for certain types of construction which would prove impossible in reinforced concrete. For instance, Professor Dischinger of Berlin has claimed that simply supported bridges with spans

up to 350 ft. can be designed. Many bridges on the Continent, particularly in France, have, in fact, been constructed using prestressed methods, and the finished effect of the comparatively slender, slightly curved arches, are very pleasing to the eye.

It has another advantage which in these times, when the shortage of steel is so acute, presents a more practical viewpoint. By the use of high-tensile steel the weight of steel can be cut down considerably. Compared with similar reinforced concrete structures the amount of steel used can be reduced from 1/5th to 1/10th. It also cuts down the amount of concrete used since the whole of the beam does useful work, instead of only part of the beam as in ordinary reinforced concrete members.

The reduction in the amount of steel and concrete, and the consequent saving in the cost of materials should.

An extract from a short paper presented to the Northern Joint Gas Association at West Hartlepool.

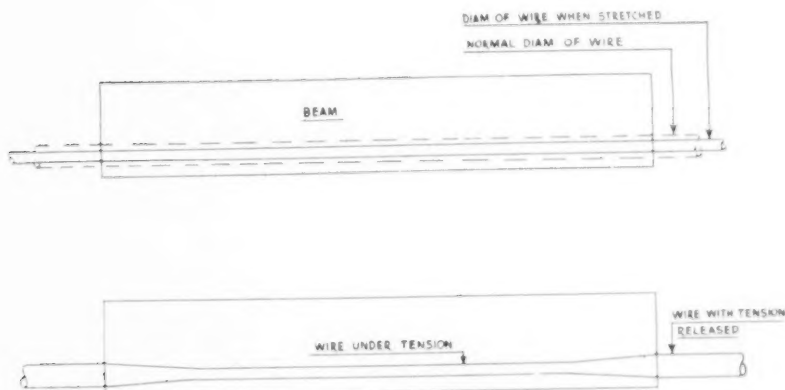


Fig. 1

CERAMICS

nevertheless, be balanced against the extra cost of the special steel and the cost of the necessary prestressing equipment. As prestressing becomes more widely used in this country the greater quantity of high-tensile steel produced to meet the increased demand will, no doubt, bring about a reduction in cost of the wire. However, eventually, prestressed concrete will have to be judged entirely on its own merits as to whether it is a better product than reinforced concrete.

Methods of Creating Prestress

There are two principal methods of placing the wire under tension in the concrete:

- (1) Pre-tensioning.
- (2) Post-tensioning.

The method of pre-tensioning is mostly used in factories producing small prestressed concrete units, such as railway sleepers, floor beams, etc., where a number of the units can be manufactured at one operation. The main part of the factory consists of a long shop generally about 300 ft. long, where the moulds into which the units are cast are laid out on benches in several lines running the full length of the shop. At one end of each line of moulds are positioned coils of high-tensile steel wire. The wires from the coils are wound off and laid inside the line of moulds, being kept in their required positions by templates suitably spaced at intervals along each line. The wires at one

end of the line are then securely fastened to an anchor block, while at the other end each wire is passed through a similar block and attached to a screw or hydraulic jack which pulls it to a pre-determined tension, sufficient to account for any losses due to shrinkage, creep, etc., and to subject the unit to the required compression needed for its ultimate use. Concrete is then poured round the wires until the moulds are filled. It is customary in prestressed concrete work to use a concrete mix having a low water-cement ratio, in order to obtain a high degree of compressive strength. In order to obtain maximum compaction of the concrete in the mould, it is subjected to a vibratory action supplied by a vibrating machine mounted on rails each side of the line of moulds which passes over and subjects each mould in turn to a definite period of treatment.

When the concrete has set sufficiently to give a bonding action round the steel the wires are cut in the gap purposely left between the ends of each mould by acetylene torch. Although the highly stressed wires are partially held by the bonding action of the concrete throughout the length of the member additional bond is created at each end due to the increase in diameter of the wire when the tension is released.

This is shown in Fig. 1, acting as a fine tapered wedge protruding approximately 3 in. into the end of the beam and preventing any further slip that

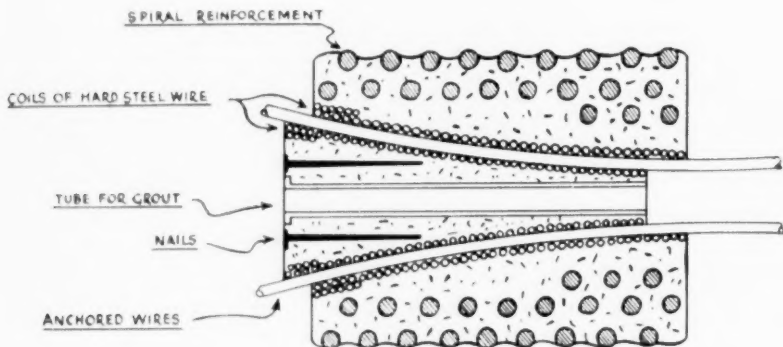


Fig. 2

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might occur. The units are then lifted from their moulds and stacked to cure for a few days, before dispatch from the works.

Individual moulds using the pre-tensioning method are also used for pre-fabrication in the factory for such sections as roof beams, pipe trestles, lamp standards, large floor joists, etc., the wires being anchored at one end and stretched at the opposite end of each mould. The moulds must be stoutly designed to take the force of prestressing without buckling. The individual moulds have the advantage that steam curing of the concrete in order to accelerate hardening can be used by placing the moulds in a steam chamber.

There are many different types of anchorages for wedging and gripping the wires after the jacks have been released, all of which operate on the wedge system. The Ministry of Works use a small cylindrical chuck with a tapered annular hole. A tapered peg in two halves fits round the wire and is centred in the hole of the chuck. When tension is applied to the wire

the peg is drawn down the taper, thereby imparting an increasing grip to the wire as the tension increases.

Post-tensioning

On all but small units, which can be easily fabricated and handled in the factory, i.e., on all major construction work where the concrete must be cast in situ, the method of post tensioning is used. The steel wires in this case are stressed after the concrete has been placed and allowed to set.

The hard-drawn wires, which are usually delivered in coils from the factory are straightened by a special machine and cut to required length. A total of 8, 10, 12, 18 or 32 wires are arranged round a steel spring of approximately $\frac{1}{4}$ in. external diameter to form cables. The cables are then wrapped with a special kraft paper and coating of bitumen to prevent a bonding action with the concrete.

These cables are then placed in the structure in the same way as the mild steel reinforcement in normal reinforced concrete construction and held in position by special riders or up-

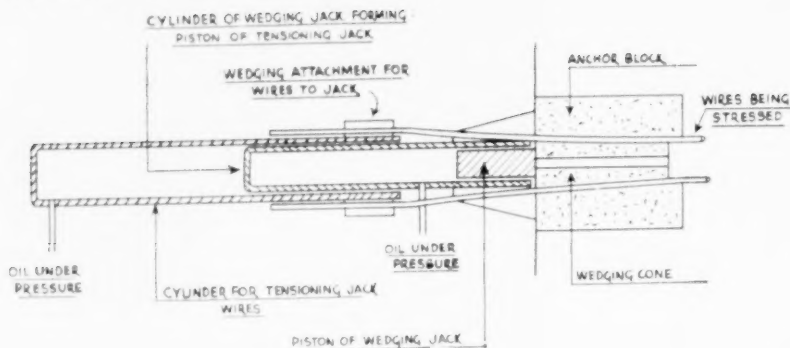


Fig. 3

rights. The structure is then concreted and vibrated as required for high-grade concrete and allowed to mature. The wires at each end are held by special anchor blocks which are cast into the main concrete structure. This system of non-bonded but mechanically-anchored cables was invented by Freyssinet, and the anchor blocks and hydraulic jack bearing his name are now widely used on this type of work.

The anchor block and cone are shown in section in Fig. 2. Both the working faces of the male and female cones consist of coils of hard steel wire, the female cone having an extra spiral reinforcement at its outer edge. It will be seen that the pulling action of the wires tends to retain the grip between the two cones and thus prevent any slip that may occur.

The Freyssinet Jack is double acting, as shown in Fig. 3, and is capable of exerting a force of 20 tons. The foot of the jack is placed on the outer edge of the anchor blocks and the wires are wedged round the outer cylindrical head of the jack. Oil is then pumped into the outer cylinder which, on moving outward causes the wires to become stretched. The elongation of the wires is measured directly and checked from a pressure gauge reading of the oil in the cylinder.

After the wires have been given the required tension, oil is then pumped into the inner cylinder, which bears on the male cone and drives it home to form a secure wedge. The jack is removed and grout is inserted under pressure through the hollow male cone to fill up the hollow centre of the cable.

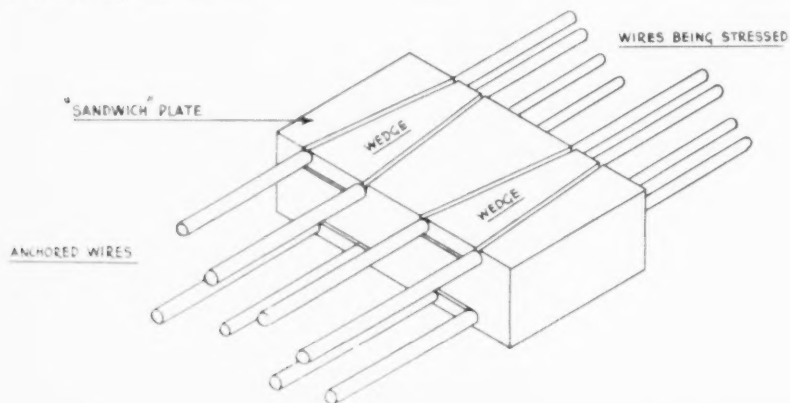


Fig. 4

The Magnel-Blaton System is also used on this type of work. The cable may be cast into the concrete in which case it is wrapped with thin sheet steel to prevent bond, alternatively it may pass through a housing in the concrete section. The wires are held in position at intervals by spacer grills, and at each end pass through the centre of a distributing plate cast into the concrete and thence to "sandwich" plates which bear on the distributing plate. Each sandwich plate (Fig. 4) anchors eight wires by means of four wedges, one wire being held by the sliding surface of each wedge. The hydraulically operated stressing jack grips and stresses two wires at a time, after which the steel wedge is driven home, the jack released, and attached to a further two wires for similar treatment.

A further method more recently developed in this country is the Lee-McCall system which employs alloy steel rods from $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. diameter to produce prestress. Tension is applied by hydraulic jack, and is held by screwing up a special nut until it bears against a steel distribution plate. An outstanding feature of this system is that the prestressing can be applied in stages and repeated stressing and un-stressing can be carried out at any time before the rods are grouted in.

Concrete Tanks.

During the above explanation of prestressed methods the emphasis has been on the fabrication of beams, columns and slabs. Prestressing can be applied, however, to other types of structures, particularly circular tanks for containing water or other liquids. Water-containing structures fabricated in normal reinforced concrete, have always been at a disadvantage, as the containing walls, especially in circular tanks, are under pure tension. As has already been explained, concrete has a very small tensile strength and, therefore, the amount of mild steel reinforcement required is quite appreciable and in practice amounts to approximately the weight of steel plate necessary were the same tank to be of steel plate construction. Apart from this great disadvantage the concrete walls will invariably crack, due to the different elongations under stress of the two materials and allow

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liquid in the tank to attack the reinforcement and also cause leakage.

By prestressing the walls of the tank to a figure sufficient to compensate for the maximum fluid pressure on the walls, and also the losses in prestress due to shrinkage and plastic flow in the concrete, the concrete becomes efficient as a liquid-containing material.

Prestressed concrete circular tanks have, and are being constructed, in this country. It is in America, however, where this method has been fully investigated and developed, and where large prestressed concrete tanks have been constructed.

One tank has a capacity of 4 million gallons, its outside diameter is 167 ft, with a side wall height of 30 ft. The total thickness of the side wall is 18 in., and the dome-shaped top cover (½ acre in area) is only 4 in. thick. Movable shuttering was used for the construction of the side walls, and after all the forms, mixing plant and distributing plants were set up the entire wall was poured continuously in 72 hours.

No. 8 gauge high-tensile steel wire, totalling 180 miles in length, was used

for prestressing the walls, and was wound round and tensioned in a most ingenious way. The method, now standard practice on this type of work, involves the use of a wheeled carriage running on the top of the wall, attached by wire cables to the centre of dome. From this carriage a platform is suspended on the outside of the wall in the form of a painter's cradle. On this platform is placed the wire-placing machine complete with coils of wire, revolving and tensioning gear. The whole assembly revolves round and round the tank at a speed of approximately 2 m.p.h., imparting to the wire the required prestress as it proceeds. When the prestressing of the walls was completed in the above case, the induced stresses in the concrete were sufficient to lift the dome 2 in. clear of its framework.

I have briefly described the construction of this tank, principally to emphasise to what extent prestressing can be used. Not only circular tanks but also large rectangular overhead storage reservoirs, aeroplane hangars, bridges, dams, multi-storey buildings, silos, etc., have all been constructed using prestressed methods.

GRAIN SIZE DETERMINATIONS

THE Pottery Section of the British Ceramic Society, at a meeting held recently at the North Staffordshire Technical College, heard a paper on "Some Experiments in Rapid Methods of Grain Size Determination," given by Mr. L. G. Leach, a student of the College, and a member of the staff of H. and G. Thynne of Hereford. He mentioned that the usual method for a rapid determination of fineness in the grinding of slip, flint, stone and glazes was the hydrometer originally introduced in 1942 by Dr. H. W. Webb and S. W. Ratcliffe.

During research work on other materials which are subjected to grinding, consideration had been given to the finding of new methods whereby the period of time necessary for determination of grain size could possibly be shortened still further. He went on to say that they were particularly interested in a procedure which would eliminate the present water dispersal method and the consequent need for a deflocculating agent.

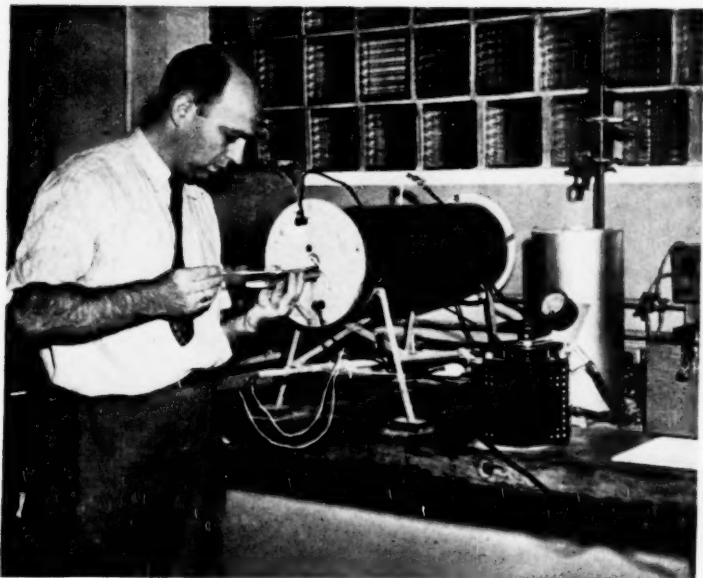
These studies led to the use of the Rigden specific surface apparatus and the Spekker photometer which, whilst

avoiding calibration by special hydrometers, would not, Mr. Leach suggested, do away with the use of the normal hydrometer method in the smaller laboratory since the cost of the new method in equipment would be a prohibiting influence other than for larger undertakings.

In a description of experimental work using both kinds of apparatus, he showed that the precise surface obtained with, for example, the hydrometer could be decided directly in relation to the other methods. With the Spekker photometer very reliable results were achieved in a short time.

A further description covered the application of the method to ceramic colours and glazes as well as for flint and stone, based on results from exploratory experimental work.

Overseas Agents.—It is learnt from Chr. Fahrner, Frederiksholme Kanal 2, Copenhagen, that they are interested in becoming agents or distributors in Scandinavia for equipment used in the manufacture of pottery.



The apparatus developed recently for study of the liquidus temperature (the highest temperature at which crystals can exist in equilibrium with a glass) and the crystallisation rate of glasses

New Method Studies Crystallisation in Glasses

(OUR AMERICAN CORRESPONDENT)

A RAPID, convenient method for determination of the liquidus temperature and the rate of crystal growth in glasses has recently been developed by O. H. Grauer, and E. H. Hamilton of the U.S. National Bureau of Standards. The technique is simple and easily mastered, making it possible for an inexperienced operator to determine quickly data that formerly required much time and skill. It thus provides the glass technologist with an effective means for assessing the effects of changes of composition on the stability of the glasses.

In the development of new glass compositions, the most important limitation has been the possibility of devitrification, or the formation of crystals in the glass, at high tempera-

tures. When this occurs, the usual result is a semi-opaque mixture of glass and crystals instead of highly transparent and homogeneous glass. Even in the relatively stable glasses now in use, devitrification may take place during manufacture if the glass is kept too long at certain high temperatures.

Two properties of a glass which greatly influence devitrification are the liquidus temperature, or the highest temperature at which the molten glass can exist in equilibrium with crystals, and the rate of crystal growth. Most of the methods used to determine these properties have involved repeated heatings at different temperatures until the liquidus temperature is reached. The Bureau's method, on the other hand, employs

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only the heating in a special platinum alloy apparatus within a gradient furnace. Thus it permits the rapid accumulation of data. This new procedure was developed for an intensive study of devitrification in glasses in order to facilitate the making of new types of optical glass having highly specialised properties. It is expected to aid materially in the development of new glasses and in solving problems arising in the manufacture of commercial glass articles.

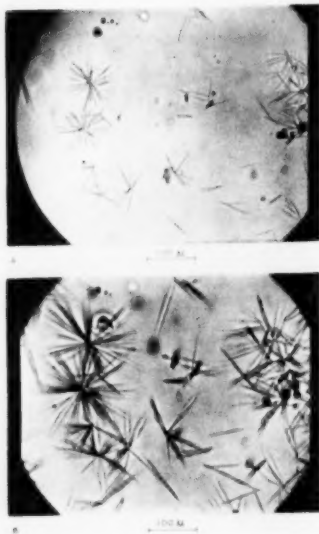
In the method, small glass fragments are placed in indented cells spaced at regular intervals along a channel-shaped platinum-rhodium strip. The strip is then inserted in a horizontal tubular furnace in which is maintained a uniform temperature gradient. Because of the small mass of the specimen and its intimate thermal contact with the platinum-alloy cell, equilibrium is quickly attained. After an appropriate time interval, depending on the composition of the

glass, the strip is air-quenched by rapid removal from the furnace. The contents of each cell are examined with the petrographic microscope, using light transmitted through an opening in the bottom of the cell. The last cell in which crystals appear locates the position in the temperature gradient corresponding to the liquidus temperature. Rate of increase in the crystal size is determined by measuring the crystals with a filar micrometer at intervals during the period following removal from the furnace.

The platinum-rhodium strip used at the Bureau is $5\frac{1}{2}$ in. long and $\frac{1}{2}$ in. wide. The cells are 1 mm. deep and are tapered from an opening 2 mm. in diameter at the top to a diameter of 1 mm. at the bottom. At one end of the channel the cells are spaced $\frac{1}{4}$ in. between centres in a single row along the length of the strip, providing a temperature difference between cells of 20°C . At the other end of the channel the cells are spaced in two parallel rows $\frac{1}{8}$ in. apart. In each of the parallel rows the cells are separated by $\frac{1}{4}$ in. from centre to centre, but since one row offsets the other by $\frac{1}{8}$ in., the distance along the channel between centres of succeeding cells is only $\frac{1}{8}$ in. In actual operation, the holder is so placed in the temperature gradient that liquidus temperature is determined within the closely spaced cells of the parallel rows and measurements of crystal size are made within the cells of the single row.

The tubular furnace consists of two concentric, grooved alundum cores separated by insulation and encased in a larger steel sheet which is packed with diatomaceous earth to reduce heat loss. The inner core is wound with platinum 20 per cent. rhodium wire along a central zone for a distance of 6 in., and the outer core is wound with a nickel-chromium alloy wire along 20 in. of its length.

Temperatures within the furnace are measured with a movable platinum-platinum-rhodium thermocouple. By adjusting the current in small windings with small variable transformers, an almost linear temperature gradient is obtained. The maximum temperature of the furnace is held constant within 2°C . by means of an electronic controller operating on a



Photomicrographs of crystals grown in a glass sample show the comparative size of crystals formed by heating at a high temperature. (A) After 13 min. at 838°C (B) After 26 min. at 860°C .

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thermocouple located in the hot zone. This results in a stable gradient in the remainder of the furnace.

Good agreement has been obtained between results by this method and those obtained by the classical quenching method. The greatest deviation for a series of determinations of five different glasses was 6° C. Errors in other gradient methods due to flow of molten glass, slow quenching, and difficulty in

locating the crystal boundary are largely eliminated. Since the entire apparatus can be placed on the microscope stage and the glass samples examined directly, positioning errors due to a broken glass specimen are also avoided. The method has proved to be very useful in the solution of devitrification problems arising in the production of large slabs of glass for interferometer plates in experimental glass plant.

COLOUR & DISCOLORATION OF HEAVY CLAY WARE

RECENTLY, Mr. W. Noble of the British Ceramic Research Association, spoke before the Institute of Clay Technology—North Staffordshire Branch—on the above subject.

In illustrating his lecture with coloured slides, it was pointed out that the colour chemistry of natural clay is very closely associated with the oxides of iron, their compounds and their various complexes. He was able to show the colour range which can be achieved by both ferric and ferrous oxides. The author emphasised that the colour after firing depended

not only upon the particular form in which the iron was present, but the firing temperature, the firing atmosphere, as well as the modifying influence of constituents in the clay such as alumina, magnesia, lime, silica, soda and potash. The author continued by showing how, by firing at higher temperatures under reducing conditions, a blue outer screen only was given to certain bricks, whilst after the reducing temperature was from 900-950° C., there was a complete blueing effect giving the well-known "Staffordshire Blue".

Face Grinding

Ceramic and Engineering Industries

THERE is a large demand for a grinder which will grind in one operation two flat opposing surfaces within close limits of accuracy and on a manufacturing scale. Some of the many components in the automobile industry are of the type represented by piston pins, piston rings, brake bands, and crosses for universal joints; in the general engineering field there are buffer and spacing washers, clutch and other plates, sleeves and gear; the ceramic and electrical trades require economically produced and accurate insulators, spacers, tubular posts and condenser parts; and in the plastics industry there are ebonite meter discs, pump discs, and so on.

A Scrivener face-grinding machine has been developed recently for this class of work, operating on the principle shown in Fig. 1. Two large grinding discs are mounted on horizontal spindles, with their cutting faces substantially parallel, so that workpieces passed between them will have their opposite faces ground simultaneously. In practice, the faces are not set precisely parallel, but inclined slightly towards each other. Each wheel-head is independent, and is adjustable to or from the opposite head by increments of 0.0001 in.

Special importance attaches to the

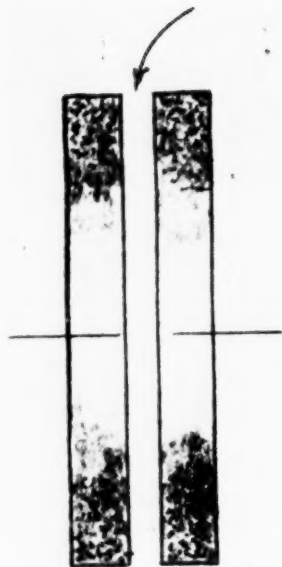


Fig. 1

truing arrangements for the discs. The truing attachment which is situated at the rear of the machine mounts two diamonds, and incorporates a compound slide which is capable of accurate movement both parallel to and at right angles to the spindles. Provision is also made for the top slide to be slightly swivelled, so that an angular face or lead can be given to the discs when required.

The machine lends itself to a variety

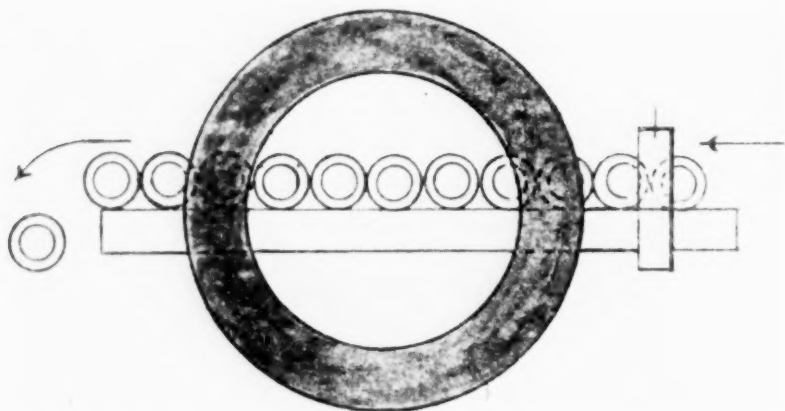
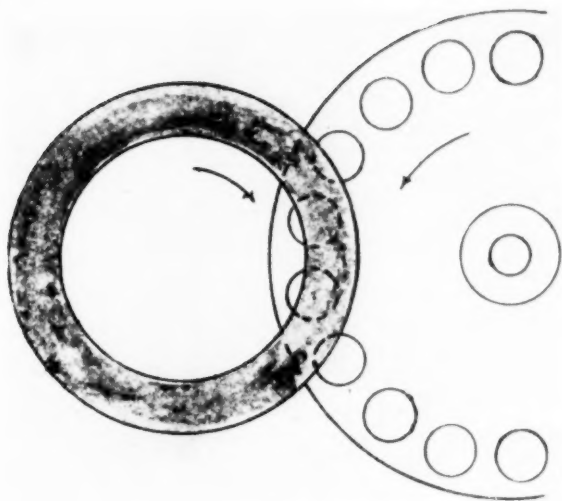


Fig. 2

Fig. 3



of automatic and semi-automatic feeds, according to the class of work involved. Large pieces, for instance, are carried between the grinding discs by means of an endless-chain type of conveyor, while many types of flat workpieces are best fed through between two vertical pressure rollers which force the pieces through the grinding passage along a horizontal work plate (Fig. 2). Other flat pieces are handled by a flat circular work carrier, of less thickness than the work, carrying a series of holes or pockets of a suitable shape to accommodate the piece, the latter being inserted by hand while the slowly-rotating work carrier transports them between the grinding discs (Fig. 3).

An adaptation of this latter type of carrier is used for the grinding of the ends of the crosses for universal joints. The circular carrier in this case has eight stations, each consisting of side-by-side V's (as shown at "A" Fig. 4) into which the piece is loaded, while axial location of the piece at right angles is ensured by a cradle having two vertical slots to receive the two arms which are not being ground. Clamping of the piece in the V's is effected automatically by the hinged compound lever "B," the upper arm of which is provided with a pressure pad which, on the rotation of the work carrier, engages the inside of the fixed semi-circular cam "D," and thus applies a gripping pressure. Any slight variation in the diameter of the piece is accommodated by a spring interposed between the two levers. With a stock removal of .050 in., the hourly production of these pieces is 1,200

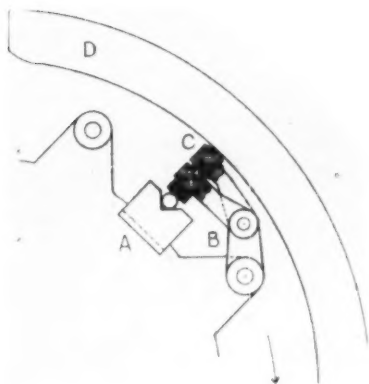


Fig. 4

double ends per hour, limits imposed on this job being plus-minus .003 in.

The main dimensions of the new machine are: Grinding discs each 24 in. dia. by 3 in. wide by 16 in. hole. Wheel head motors each 20 h.p. at 1,440 r.p.m. The work-head motor has sixteen speeds, and the maximum distance between faces of new grinding discs is 11½ in.

Multi-duty Air Filter.—In the April, 1952, issue, a Multi-duty Air Filter, manufactured by Air Control Installations Ltd., Ruislip, Middlesex, was described as a "multi-ray" filter: the point is that it is a Multi-duty Air Filter!

Industrial Gas Conference—Birmingham

What Industry Wants from the Gas Industry

by

J. WALKER

LET me, as a starting point, give you six basic convictions widely held and often announced—to which I heartily subscribe: (1) Coal isn't just a fuel, but a valuable raw material forming the foundation of our whole economy. (2) As such, it is sold too cheaply. (3) It is a long-standing crime that so much of it is burnt raw, wasting the by-products, polluting the atmosphere and causing monstrous damage to assets which we now can never afford to replace. (4) Our industrial productivity must be stepped up materially and quickly. (5) Our shrunken capital resources have to be used to much greater advantage which not only means more effective but more continuous utilisation of our plant and equipment. (6) No other nation can surpass the results of our inherent flair for research. We must do more of it, but, even more important, it must be linked with greater readiness and cultivated ability to apply the results quickly in industry.

How does all this affect the user and maker of gas? It means the using industries want more gas—though they may not appreciate it other than in a very general way—and that the gas-making industry has to be prepared

to make a lot more gas and both educate and motivate industry to use it properly.

It would be inappropriate for me to get too involved in the matter of your industry's capital investment programme *vis-à-vis* that of the electricity generating authorities, etc., but many in industry believe the gas making programme is too small.

It has been suggested that this programme may have been restrained in an endeavour to be realistic and that it represents a sensible demand on scarce materials, scarce capital and the not unlimited resources of the gas plant contractors.

Such stark naked thinking would certainly be appropriate to the times, but if indeed this is the trend of thought, I trust it will go further and promote the frugality that plans chiefly in terms of a maximum of plant renewals, reconstruction, simplification rather than a smaller programme of more elaborate innovation.

The obvious need for continuing the integration and long-term reorganisation already going on in the gas industry has its dangers. As Winston Churchill once said: "Sir, we must beware of needless innovation, especially when guided by logic."

Mr. John Walker, an industrialist, was guest speaker at the morning session, and this was a worthy effort because he had no direct connection with the gas industry. He is a director of the Morgan Crucible Co., and of Morganite Incorporated, New York, also managing director of Morgan Refractories Ltd., a director of the Douglas Firebrick Co. Ltd., and chairman of the Whitting Fireclay Co. Ltd.

But is this restraint in forward planning really realistic? I'm going to suggest it isn't and back this viewpoint by two main threads of argument.

First, it surely cannot be reconciled with the attainment of the gas industry's rightful place in the National economy? Mr. J. H. Dyde—speaking as President of the Institution of Gas Engineers—has said the gas industry will get due recognition when the shortage of coal really seriously bars further increase in productivity—and this might be soon.

Key to Problem

"Soon"—perhaps it is this matter of timing which is the key to the problem. Is the gas industry and/or others concerned with this programme looking back at the relative slowness of past progress in industrial use of gas and thence under-estimating the possible rate of future progress? The earlier stages of development were slow. The first recorded use of gas in industry for purposes other than lighting was, I believe, for tool heating in 1838. In the late 18's Thomas Fletcher was emphasising the potential demand for industry. Some 20 years ago Dr. Walters was not only saying how gas could meet competition, but also enter many fields previously unsuitable. Many others have kept up the theme. Some areas have also done much yeoman practical work in the field and, no doubt, found the going tough.

But has the more recent gathering

of momentum been truly assessed?

The "Heyworth" report predicted a 20 per cent. increase in gas sales between 1945 and 1955. In fact, by 1949 50 gas sales rose by over 27 per cent.

Have you looked closely into the rate of development in associated fields? Some in which this country was lagging are now the scene of much activity and often unsuspected progress. I'm thinking especially of the refractories industry—long a humble sister much concerned with traditional craftsmanship and handicapped by excessively low price levels, but now modernising and improving with great rapidity. This is allowing big improvement in furnace design and making practical the ambitions of technologists in many heat using industries.

All this is adding up and there is likely to be surprise not only at the total but the speed of its mounting.

The F.B.I., I note, in submitting evidence to the Committee on National Fuel Policy has stated that, judging by *present trends*, there should be a 40 per cent. increase in coal consumption in the gas industry by 1960-65. The situation deserves that all bodies able to speak with authority should give the Government, through every appropriate channel, a bold forward-looking picture of the rôle the gas industry has in a sound National Fuel Policy. Given due recognition and support our national genius for rising to the occasion can



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he relied upon to cope with the difficulties of execution.

I've said enough about what is wanted quantitatively and must turn to qualitative features. These are naturally associated with trends in the heat using industries.

Space Heating

Today I believe even the most dyed-in-the-wool reactionary, whatever he may think of the Welfare State or however "agin coddling the workers," must be convinced that the trend in legislation and practice to make working conditions more hygienic and comfortable is plain sound common-sense. My experience of space or water heating by gas is confined to the use of high temperature radiant heaters. They are effective and attractive because of the relatively low installation cost. There is still scope, however, for further improvement in appliance design. Simple robustness is essential, so that the heaters can be kept clean and efficient with a minimum of attention.

There is no need to say much about drying processes. The progress in this field has been one of the outstanding examples of initiative and education by the gas industry.

Furnaces

So to ovens and furnaces. Industry is and wants to go on making greater use of continuous-type ovens and furnaces not only for fuel economy's sake, but because it wishes more and more to ensure that each and every article it makes receives the same predetermined heat-treatment.

Basically the continuous furnace is the right approach and the last 20 years has seen its widespread application from bakery ovens to enamelling, steel heat-treatment, etc., whilst today a large proportion of the tableware we eat off has been so fired.

Installing such furnaces, however, like a wedding ceremony, is only the first step and, to the user with an eye open for reducing wastage, often brings temporary disillusionment. A continuous furnace, as its name implies, has to be continuously fed and discharged and all is well, while conditions are satisfactory, but if furnace conditions go awry products

must still go in and come out in a continuous stream—faulty.

Such trying situations have brought many grey hairs to management, and it is an obvious requirement that combustion in continuous furnaces should as far as possible, be automatically controlled.

To the gas industry this is both a challenge and a help.

No fuel better lends itself to automatic control than gas, but the burners must receive gas at constant pressure and not only constant calorific value but with constant burning qualities. My experience is that calorific value is well maintained; pressures are variable, but this matter at least receives sympathetic consideration; in some districts, however burning qualities would seem to be regarded as of lesser significance. This is a mistake and it is stressed that the recognised test burners should be much more widely and regularly used than seems to be the case.

Conversely, since there are practical limits to the degree of control which the gas making industry can afford to apply to the quality of its gas, there must be co-operative reconciliation of users wishes and the supply practicabilities. Education is the answer to the stipulation of arbitrary limits on the quality of supply. Additionally, the current work on the design of burners less sensitive to small variations in gas quality needs to be accelerated.

Design Points

These pleas are reinforced by other trends in furnace design. Designers are trying more and more to burn the fuel much nearer to the point of application and to let the products of combustion get at and uniformly bathe the articles being heat-treated. This not only increases the direct fuel economy for the obvious reason that less heat is wasted heating up remote parts of the furnace structure, but aims at still greater efficiencies by increasing the furnace's payload of saleable ware.

Remarkable changes are being effected in pottery kilns, for example, where in old-fashioned units plates were heavily buried in dust and the whole encased in heavy fireclay boxes

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or saggars. The ratio of such kiln furniture to saleable ware could be as high as 6 or 8:1, whilst in modern kilns, aided by stronger refractories, much pottery is placed open on comparatively light supports, reducing the ratio of kiln furniture to ware down to as low as 1 or 2:1.

This is only possible, however, if the products of combustion to which the ware is exposed are clean and unarmful—free from entrained dust or ash or excess of gaseous impurities, such as sulphur compounds.

Need I name the ideal fuel?

Willy nilly, some processes, however, do not lend themselves to heat-treatment in continuous furnaces, but the products must be charged into, heated, cooled in and discharged from batch-type units.

Fundamentally such furnaces tend to be much less efficient and at present in many, only about 10 per cent. of the heat in the fuel is effectively used.

It is well known that in most furnaces of this type the ware is processed much more slowly than is

necessary. Substantial fuel economies and improved productivity can be obtained if the ware can be brought up reliably and uniformly to the fastest safe heating curve. Gas lends itself most readily to the necessary combustion control, but, even given ideal combustion conditions, by far the greater part of the heat released from the fuel is lost up the chimney or absorbed in heating up the furnace structure itself.

Stack losses can be minimised by sensible use of recuperation or regeneration, and I need not remind you that Town's gas, with its high ratio of combustion air, is an ideal fuel for use in association with these heat recovery devices.

Low Heat Capacity Refractories

Today, however, much improved low heat capacity refractories are readily available for lining batch-type furnaces. Suitable for use up to 1,600° C. if need be, such bricks require less than half as much heat to raise them to a uniform temperature as do normal firebrick and when

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built into a furnace wall their resistance to heat penetration reduces their heat absorption much further. Furnace walls may be thinned and existing units increased in capacity, and new furnaces have such a light structure that supporting steelwork is much reduced.

The only limitations of these refractories are their low resistance to mechanical abrasion and erosion by slags, and gas is the ideal fuel to use with them—or is it the other way round?

The magnitude of the fuel economies achievable can be as high as 80 per cent. of the fuel employed in older type furnaces but, even more important, with much more rapid heating and cooling of the furnace productivity is much increased.

So far I've baldly outlined the direct potentialities of gas as a fuel. It doesn't stop there. Dr. Fells, back in 1934, spoke of the potentialities of gas in the steel trade and rightly emphasised the additional possibilities of savings in after-processes. He put it succinctly, if I remember correctly, by the challenging statement that if grinding and/or pickling operations were necessary after heat-treatment then the advantages of gas were not being used. He was referring to the potentialities of controlled combustion and furnace atmospheres to prevent or minimise surface oxidation and scaling. This principle has been actively taken up, but the potentialities for still wider use are by no means exhausted.

Safety Measures

In some quarters there has been justifiable concern over safety precautions when using gas. To the gas maker, having an everyday familiarity with this fuel, certain precautions have become second nature. To the industrial worker, however, the gas is often something quite incidental to his work and skills—something that comes out of a tap, and if gas is to be more widely used in industry appropriate safety measures are essential. The recent publication by the Factory Department of the Home Office on safety in design of gas-heated ovens and furnaces is of appreciable significance. The Factory Inspectorate—never were so many unjustifiably

thought so little of—are going increasingly to require a higher standard of safety. This trend should be welcomed and will, I trust, hurry on the development of less costly, simpler and more foolproof safety appliances.

Some of you may be wondering if I'm selling you gas or the other way round.

More may be thinking—yes this all very well, but you are a convinced user, others seem much less ready to be convinced. I'm going to disagree—you'll find the same general conviction running through industry, but there is a world of difference between having a general conviction and being induced or able to go out and do something about it in specific cases.

For one thing, for something like 12 years some British industries have not frankly had to worry enough about quality and cost. The prolonged sellers market and the many difficulties of getting new equipment have not provided much incentive to pursue a progressive policy. It won't do and it won't last, and, thank goodness, many have not been lulled into a sense of false security. For another, industry has by taxation been heavily drained of its resources for fresh capital investment. The pleas for taxation relief on fuel saving schemes should be strengthened and pressed home.

To a large extent, however, I'm going to throw the responsibility back on the gas industry.

Selling Gas

Your publicity for the use of gas in industry is very good and the quality of the technical pamphlets setting out the case for gas in particular trades, in particular, reaches a very high standard. Such work is very necessary, but in the final run more gas will be sold to the industrial user by practical specific recommendation and conviction "on his own shop floor."

May I, therefore, with all humility, suggest to you the best basis for selling industry more gas.

First the gas should be there to sell. The gas industry must fully sustain its reputation for reliable supply—it would do immeasurable harm if demand were further stimulated and the supply not forthcoming.

The gas industry should approach

its task with a genuine and knowledgeable conviction of the soundness of its case and concentrate on those applications where gas has genuine advantage. It won't need to go any further. It must be prepared to make its case and recommendations concrete and specific.

So far as lies within its power, the gas industry should ensure that any plan or appliance it recommends can be relied upon to give a certain standard of performance under normal industrial conditions. An approved list technique greatly commends itself for use throughout the country—as some area boards must know from their own experience. The recently announced plan for collaboration between The Gas Council and the Society of British Gas Industries is most welcome and should assist in promoting useful and sensible standardisation.

Area demonstration units have their proven value as part of the pattern of good sales promotion and service, but I recall reading somewhere in gas industry literature a description of them as centres to which industry could bring its problems and difficulties.

Such facilities are not more than a necessary tool to a staff organisation with an adequate number of well-trained staff who go out, collaborate with and give practical help to the industrial user in his own plant.

Consumer Service

Consumer service is interesting work for good calibre men and if the gas industry has difficulty in finding enough of them, it must to some extent blame its own modesty in not publishing as actively as some other industries its potentialities for employment or its often excellent staff training schemes.

Others are better placed to advise upon the expansion and organisation of these training schemes, but obviously they must aim at teaching the service engineers what gas will and won't do and giving them a broad appreciation of users' industries and requirements. However, may I plead for a special effort to ensure that they also have a thorough practical appreciation of modern refractories and their usage. It won't be easy to provide—much of the available literature

is not all that helpful and the subject is treated with scant courtesy in many educational establishments, but, as already mentioned, refractory manufacture is undergoing a revolution and the extended use of gas and these refractories must go hand-in-hand.

A Fine Record

The gas industry has naturally always taken a keen interest in refractories and their usage in its own plants. It has given strong support to research on refractories. Of the tonnage of coal going to public utilities, services and industry, the gas industry uses 17 per cent., but of the insulating refractories hitherto produced in this country in limited quantity and quality it uses nearly 50 per cent. A fine record which will, I'm sure, not engender any complacency but encourage further progress. But I wonder how many people in industry know of it and to what extent do your service engineers take the lessons with them in advising on gas usage?

Here a word on discretion might not be untimely. No sensible user drawing on pooled knowledge of gas usage will object to his experience being added to the pool, but he does expect his own trade secrets to be safeguarded and will quickly close his door to the gas engineer if they are not.

When a sales engineer starts to give details of a competitor's processes he unsells himself and his employers in double-quick time. Remembering the old saying "the more you say the less your hearers remember," let me most briefly recapitulate.

My view is industry wants to see:

True recognition of the rôle the gas industry has to play in the national economy.

Much more gas with constancy in supply, pressure, calorific value and burning qualities.

A high standard of gas cleanliness and freedom from sulphur.

Practical, simple, flexible and robust gas burning appliances of approved performance.

Inexpensive, robust, foolproof safety devices.

Plenty of practical consumer service on the shop floor.

I must not close without dealing

CERAMICS

with the important matter of the price of gas. The current literature reveals concern over price trends, justified by the obvious need to ensure that gas prices are kept competitive. I'm not going to get involved in political considerations or controversy on the relationship between domestic and industrial gas prices, or the effects of present electricity tariffs, etc.

I would, however, sum up the matter this way and ask you as businessmen, to give full weight to few words. Industry wants large quantities of gas—often round the clock—rarely for short peaks. The industrial gas demand is, therefore, essentially a flywheel or base load—a spreader of

on-costs—and, as such, must be priced on its merits.

As you all know full well, you are the custodians of an industry already responsible for ensuring the optimum use every year of 27 million tons of this country's most precious natural asset—coal. No industry has a better record of responsibility—none in my opinion, such opportunities for continuing to exercise it for the national good. There are excellent technical and economical reasons why you should have further greatness thrust upon you. My plea is that you adequately prepare for and do accept it. Many other industries envy you your opportunities.

BIRLEC LTD.—SILVER JUBILEE

At the Silver Jubilee luncheon of Birlec Ltd., held recently in Birmingham, Mr. J. H. Crossley, B.Sc., Wh.Ex., said:

To review 25 years' progress in 10 minutes is an impossible task; it is, however, a task which is simplified by the fact that you already know something about our affairs at Birlec and also because you will have this afternoon, an opportunity of looking around our main offices and works at Tyburn Road. I hope—and believe—that you will think when you go home tonight that we have made a good impression.

We claim to be the largest organisation of our kind in the world making furnaces and allied equipment only; not motor-cars nor biscuits nor cotton goods nor anything else that is mass produced, but primarily tailor-made equipment. We are by manufacturing process, a general engineering works still depending largely on the personal skill of the fitter and the electrician, the welder, the plater and the bricklayer—after, of course, the designer, the technician and even the salesman have played their parts.

By tonight, you will have seen all this. It is, however, my task now to say something about the 25 years' gap and tell you how we have reached our present position.

Birmingham Electric Furnaces Ltd. (as we were known until just after the war) was started as a new outlet for nickel alloys; we were then part of Henry Wiggin and Co. Ltd. and still

today are sister firms with this company within the Mond Nickel and International Nickel organisations. The outlet for nickel alloys which we explored lay in the manufacture of industrial electric furnaces and we grew up, it might be said, with one chief aim in view—the provision of equipment to ensure efficient and economical heat treatment. We have, it is true, digressed in many directions since the early days and I will deal with some of these developments later; but all the time our central and main purpose has been to provide industry with reliable engineered heat treatment furnaces. To underline the word "reliable," I can mention that the first furnace we sold, a quarter-of-a-century ago, is still in daily operation.

We started, too, on the firm foundation of having a metallurgist and scientist as our chief, A. Glynn Lobley, or A.G.L. as we knew him, was well known to many of you gentlemen, as he was a prolific and authoritative contributor to many of your pages. To us, of course, A.G.L. was far more. He had a brilliant technical mind, and a character—stubborn if you like, meticulous certainly—which refused to be daunted. With that combination of qualities he solved many problems and we can count to our credit many pioneering designs which, after first appearing hopeless, were by persistence solved. I could mention many types but will confine myself to three; the rotary drum annealing furnace—over 200 of which were produced in

wartime and in which the vast majority of cartridge cases were annealed, not only in Great Britain, but throughout the Empire; the duplex nitrider for aero-engine crankshafts and liners—a similar number of which were made—after one of our first orders had been cancelled because, in accordance with the best German industrial opinion, our design would never work; and thirdly, our malleable annealing equipment—now spreading round the world—and, which is mercifully, I am pleased to say, a furnace used mainly for peacetime purposes.

As we have introduced completely new furnace designs, so also have we pioneered new heating applications in this country—continuous furnace copper brazing, continuous bright annealing, gas carburising, to mention but three. And, if we can be said to have specialised in any particular problems, they are doubtless the metallurgical ones involved in the application of gaseous atmospheres and the mechanical ones in designing various types of continuous conveyor equipment.

As I mentioned before, our attention has widened and we might be said to have departed in many ways from our original brief. We now, for example, make gas-fired equipment which, although using a large amount of nickel alloys, does not depend on their resistance qualities for the generation of heat. And in this connection, it might be claimed that the successful development of electric furnaces has stimulated gas furnace designers to greater efforts—away from their original box-of-bricks ideas.

The Melting Field

A larger deviation has, however, been into the melting field where electric equipment shows much the same sort of general advantages over cruder forms of firing as are apparent in heat treatment applications. Here, on the whole, we have followed the best practices of American design and our main types of melting furnaces are, in fact, based on those of our American associates. We started with the indirect arc unit; just before the war we installed our first direct arc type—on six weeks' delivery; latterly, in collaboration with the Ajax-Northrup people, we have built high frequency induction units for steel and also low frequency induction units for aluminium and other non-ferrous alloys.

Induction melting, of course, will remind some of you of our part in providing induction heat treatment equipment—which some people hopefully consider to be the future answer to all heat treatment problems.

All in all we have built and can build a type of electric furnace for every heat

treatment and melting process.

My remarks so far will mainly have been of significance to the editors of those journals directed to the metal engineering trades but, by the representation here of other journals, you will guess that Birlec interest extends to even wider fields. Two of these are simple developments of heat-treatment furnaces—pottery and cremation. Those of you who have ever passed through the Potteries will remember the characteristic skyline broken by the bottle shapes of the conventional fuel-fired kilns and may regret that this picturesque sight is slowly dying out. We are instrumental in this decay—although decay is possibly the wrong word for a process which is bringing greater efficiency and economy, and vastly improved labour conditions, to this important industry.

Cremation, too, you may think an odd interest for furnace manufacturers; it accounts, indeed, for only a small part of our production and yet we consider this matter of great importance. You must remember that we are mainly bound up in our work with the dull, prosaic details of technical development in the metal industries, and cremation is, therefore, to us an opportunity of direct social service to our fellow-beings.

Lectrodryers

Last of all in our manufacturing interests, I come to deal with the Birlec-Lectrodryers or, as our chemists call them "non-chemical moisture adsorbers depending on the properties of activated alumina." Although this type of equipment is now of special application to the chemical and general engineering industries, it is interesting to record that dryers originated as a metallurgical application—to dry the atmosphere in a bright annealing furnace. Since then the potential demand for these dryers has widened so much as to appear insatiable, and includes tablet packing, chocolate and sweet handling, chemical processing, general engineering with all its uses of compressed air, electrical manufacture and anywhere, in fact, where water, quite literally, can gum up the works.

I do not want to complete this review without mentioning a topic of great current moment—export. Foreign business has, for Birlec, a special significance and, for this, I must take you back to the early 1930's when, like other firms, we felt the keen draughts of national depression; nobody wanted capital goods and we were faced with the day-to-day threat of shutting shop. We were saved by one large export order; where from it might not be politic to mention, but I can perhaps give you a pointer by surmising that

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even today, those Birlec furnaces may still be annealing one side of the Iron Curtain.

Since this order, we have never looked back and have always attempted to spread our products throughout the world. This policy is now earning us hard and other currencies and, of course, the indirect impact of our furnaces and dryers on the export market can never be estimated—I for one, would not mind just 1/100th of 1 per cent. of the "export only" pottery that has been fired in Birlec kilns.

Firm of Individuals

Finally I would like to touch on the personal or—if you prefer a jargon word—the personnel side of Birlec. Although we employ nearly 800 people, we are still a firm of individuals as it is on individual skills that our products depend; and, by the evidence of long service, our people seem to like working with Birlec. We are fortunate, indeed, in belonging to a much larger industrial organisation and are thus able to afford recreational and other facilities which might not otherwise be possible for us. We have, for example, a non-contributory pension scheme—a very generous benefaction. We have a finely appointed sports field quite removed, I am glad to say, from the factory site, which can be a depressing place on Saturday and Sunday afternoons. Our sports clubs cover most interests, our latest recruit being a baseball section. We hope we are not behind with our canteens and more ordinary amenities; and, in fact, we would hasten to improve and add to our social facilities if only we could get the necessary building licences.

Well that, gentlemen, very briefly, is Birlec. We are now fully 25 years old. We are still a young firm—still a first generation firm. We have our eye to the future—and, if you remember that there is hardly a single end-product in the metal trades that does not depend at several stages on efficient melting and heat-treatment processes, we are not despondent.

The Factory

An opportunity was afforded for visitors to see round the Birlec factory, the employees of whom have grown from about 300-600 in 25 years. In this period the firm has moved from George Street, Birmingham—to say the least of it, modest accommodation—to a factory at 95 Tyburn Road, which is anything but modest, and which incidental to its technical skill launched out into civil engineering by building a complete factory bay about 140 yards long over an existing canal.

The first Birlec furnaces were simple, brick-lined, steel-cased boxes heated by resistance elements of nickel-chromium alloy arranged on the walls surrounding the charge space. Refinements were, however, quickly developed; the patented hook method of securing elements soon came; door heat control was another early achievement; larger furnaces created problems of temperature uniformity which were soon mastered. In not many years, Birlec reputation was securely founded on a range of standard, box-type furnaces in daily use for such heat treatment applications as hardening and tempering, annealing, carburising, etc.

The next big step was the manufacture of conveyor-type equipment and even the non-user of furnaces can imagine what problems thus arose. At high temperature, moving parts behave quite differently from when they are cold; new materials have to be discovered, new designs worked out and tested, whilst the retention of a protective atmosphere in a continuous furnace is obviously difficult. All these problems and many others were, by experiment and experience, overcome and standard ranges of conveyor-type furnaces gradually evolved: mesh belt, roller hearth, pusher, rotary drum, walking beam—all types now quite familiar.

Furnace Atmospheres

Parallel with these developments of furnace designs, proceeded work on furnace atmospheres and to their credit lies much pioneering in this country on such processes as electric furnace copper brazing, continuous bright annealing, gas carburising and the gaseous method of annealing malleable castings.

The growth in this country of an electric furnace industry stimulated the older-established gas interests to greater activity and more efficient designs. It thus came about, in a healthy competitive market that Birlec was often asked to provide gas-fired equipment, and success in this field is shown by the increasing number of Birlec gas-heated furnaces installed.

Many large melting furnaces of various types and sizes are made. The large Birlec-Lectromelt furnaces, of up to 50 tons capacity is mainly for the steel industry. Small, horizontal, Birlec-Detroit indirect arc furnaces are used principally for melting irons and non-ferrous alloys. Other designs of melting furnaces are of the induction type; Birlec-Northrup high frequency equipment is used in steelworks and for melting nickel and other metals, whilst Birlec-Tama low frequency induction

furnaces have particular application in the aluminium and other light alloy industries.

The latest development in industrial heating is the use of electro-magnetic induction and there is a separate division organised to promote the sale of equipment for this purpose. The process is particularly applicable to localised heat treatment and the heating of billets for forging, extrusion, etc., and many Birlec induction heaters are installed in the automobile and other industries.

Dryers are now an established part of production; interest in them originated from the need to remove moisture from furnace atmospheres but the range of applications has since been extended to cover a wide variety of chemical, pharmaceutical, food processing and engineering industries.

A furnace begins to take its recognisable shape in the plating and welding section, where steel plates and sections are marked out, cut and joined to form the outer casing.

Meanwhile, the components for the numerous mechanisms which form part of modern furnaces are turned, bored, planed, or otherwise shaped in the machine shop.

The assembly of mechanical parts in the fitting section may involve the complete shop-erection of the final installation and a pit provides room for handling the largest jobs. Besides bench work of all kinds, the fitters produce woven wire conveyor belts, induction heater coils and many other specialised items.

An important part of any furnace is

its lining of refractory brickwork and this is usually installed when the casing is finally erected on site. In the brick-laying section, special brick shapes are cut on a high-speed wheel or may be moulded in refractory cement as required.

Electrical work includes not only normal cabling—often of very heavy capacity—but a variety of special jobs, such as forming heating elements and busbars, wiring instrument panels, and assembling thermocouples and heat fuses.

The Pottery Trade

Readers of CERAMICS will be most interested in the contribution made by Birlec to the pottery trade.

A full awareness has been recognised by the management in terms of design about 80 draughtsmen—and an organisation to give service on the customer's floor. Where it is a simple problem of brazing or a relatively complex tunnel kiln the resources of the research laboratories of the Mond Nickel Co. are available. Conveyor belts for pottery kilns can be an expensive item but Birlec having found difficulty in delivery from the experts decided to make their own belts with a corresponding reduction in cost. Add to this excellent canteen facilities, a pension scheme, a healthy recreation and sports club, and it will be appreciated that in the instance of Birlec one is discussing an organisation which has combined the importance of production with the importance of welfare of its employees on an adequate scale.

REFRACTORY LININGS

THE newest, and one of the most important refractory applications of carbon and graphite materials is in blast furnace linings. This was common practice in Germany before the war, and really caught on in this country in 1945. About 25 per cent. of American blast furnaces are now partially carbon lined.

Carbon is also used to line ferro-alloy furnaces and furnaces used to produce phosphorous and calcium carbide. It is the only lining material that will withstand 3,600° F. in the carbothermic process for making magnesium. It is also used in making beryllium oxide and beryllium copper, where temperatures up to 3,600° F. are common. In the production of aluminum, about 7½ lb. of carbon lining are required for every 100 lb. of aluminum produced.

Furnace linings are usually made with carbon blocks, with joints filled with carbon paste. The paste joints bake

into solid carbon when the furnace heats up. The blocks can also be machined to fit up into close joints. In complicated linings, where a good deal of machining is required to fit up the lining, graphite is sometimes preferred to carbon as a lining material in spite of the higher cost and heat conductivity of graphite.

In addition to blast furnace linings and wall sections, cinder notch liners, run-out troughs, mould plugs and stool inserts are also made of carbon. Freedom from sticking, the absence of inclusions, light weight and mechanical strength are the chief features of carbon as a plug material. Carbon is easy to fabricate in the shapes required for both plugs and stool inserts. Hot steel does not wet carbon and will not stick to these parts.

Materials and Methods (U.S.A.), April, 1952.

BRITISH CERAMIC SOCIETY

THE following are abstracts of papers which appear in the April, 1952 Vol. 51, No. 4, *Transactions of the British Ceramic Society*:

Bricks and Clays of the Hastings Beds, by B. Butterworth and D. B. Honeyborne: Samples of bricks and clays have been taken from twelve brickworks using clays from the Hastings Beds. The bricks are shown, by modified British Standard tests, to vary widely in strength and porosity, to have low to moderate soluble salts contents and only a very slight or negligible tendency to effloresce. They are, in general, likely to be durable under severe exposure.

Chemical analyses and differential thermal curves of a representative selection of the clays and of the particle size fractions of some of them are presented. The fine fractions of some of the clays have also been examined by X-ray diffraction. The results show that the clays consist of varying proportions of clay minerals and accessory minerals. The accessory minerals are free silica (quartz and other forms) calcite, gypsum and iron hydroxides and oxides such as goethite, haematite and lepidocrocite. The

clay minerals are illite, kaolinite and a chlorite-like mineral. On the basis of some necessarily speculative assumptions, a quantitative estimate of the amounts of these three minerals has been made. This has indicated that they are present in about equal proportions, but with some variation from sample to sample. There was not enough evidence to enable definite conclusions to be drawn about the structure of the chlorite-like mineral.

The relation between the mineral composition of the clays and their ceramic behaviour, as indicated by a deformation-under-load test, is discussed. Correlation is difficult, because the properties of the chlorite-like mineral are not well-defined, but the results tend to confirm the conclusions of Grim and his co-workers. The mechanism of the bloating of some of the clays is also briefly considered.

pH/Viscosity Relationships in the System Zirconia-Water-Polyvinyl Alcohol-Hydrochloric Acid, by P. D. S. St. Pierre: pH/Viscosity relationships are given for some zirconia suspensions. It is shown that the viscosity of a slip is determined by pH, particle size, and



A corner of the joint Electrical Development Association/Midlands Electricity Board stand at the B.I.F., Castle Bromwich, showing one of the live demonstrations—throwing the clay with a motorised potter's wheel

percentage of solids present. Polyvinyl alcohol (PVA) added in small quantities to improve the green strength of cast ware has little effect on the slip. 70-80

per cent. zirconia by weight suspended in 1 per cent. aqueous PVA solution at pH 1.5-2.0 is recommended as a good casting slip.

MANESTY MACHINES LTD.

AMONG the articles of equipment demonstrated at the B.I.F. was the Manesty gas-heated automatic water stills, on the Gas Council stand at Birmingham, whilst members of the staff of Manesty Machines Ltd., on stand D.35 at Olympia dealt with enquiries relating to mechanical or processing problems.

Among the machines of interest was a

tablet processing machine which is totally enclosed and well guarded for safe operation, whilst although designed primarily for single punch for large tablets, multiple punches can be fitted. A stainless steel mixer of new design was shown to demonstrate how to mix intimately powders and moist material especially suitable for tablet granulation. A transparent plastic dust cover enables the mixing process to be observed.

BRITISH CERAMIC SOCIETY

Refractory Materials Section

A ONE-DAY meeting of the Refractory Materials Section will be held in the Library of the Royal Sanitary Institute, 90 Buckingham Palace Road, London, S.W.1, on Thursday, 5th June, 1952. The programme is as follows:

Business Session

9.30 a.m. Meeting of the Section Council (council members only).

10.00 a.m. General Business Meeting of the Section.

Morning Technical Session

The following papers will be presented and discussed:

10.30 a.m. "Further Investigations on the Sintering of Oxides" by Dr. P. W. Clark, Mr. J. H. Cannon and Dr. J. White.

"Firebricks and the Reheat Test" by Mr. J. F. Clements.

Afternoon Technical Session

2.30 p.m. "The Quantitative Determination of Minerals in Ceramic Materials by Thermal Means" by Dr. R. W. Grimshaw and Prof. A. L. Roberts.

INTERCHANGEABLE HEAT-EXCHANGER

WHAT is claimed as the world's largest standard interchangeable heat-exchanger unit was exhibited for the first time at the British Industries Fair at Olympia, London, by Quickfit and Quartz Ltd., manufacturers of scientific and industrial glassware of Stone, Staffs, a member of the Triplex group of companies. The heat exchanger is designed for incorporation in 18-in. diameter HCL absorption columns.

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APPOINTMENTS VACANT

PHYSICAL CHEMIST or CERAMIST to install and operate a pilot plant manufacturing ceramic materials for piezo electric applications. For the first year applicant would be required to develop certain production operations including the extrusion of ceramic tubes. Applicants should have a science degree and a few years experience of electrical ceramics production. Salary £500-£750 depending on age, qualifications and experience. Box No. 11, CERAMICS, 157 Hagden Lane, Watford, Herts.

APPOINTMENT VACANT

REFRACTORY MANUFACTURERS in the North with six Intermitent Kilns, require assistant manager to take charge of setting, burning and drawing. Progressive position for first-class man. Starting salary not less than £600 per annum. Box No. 12, CERAMICS, 157 Hagden Lane, Watford, Herts.

MANUFACTURING RIGHTS

IMPORTANT FRENCH COMPANY wishes to negotiate with a firm of repute for a licence to manufacture carbon bricks. This firm is seeking to contact erectors specialising in special kilns from carbon bricks. Box No. 13, CERAMICS, 157 Hagden Lane, Watford, Herts.

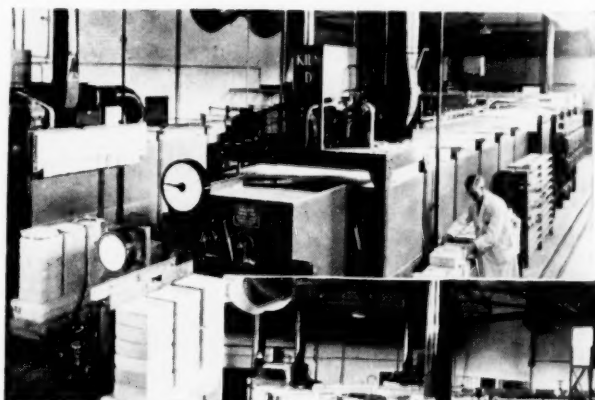
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Subscription Rate 25s. per annum.
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Telegrams: "Techpress, Watford." Telephone: Gadebrook 2308 9.*

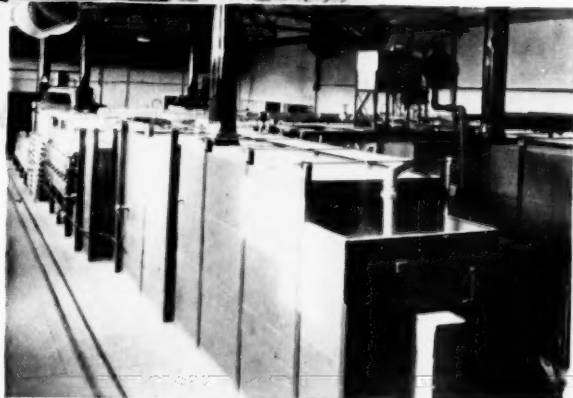
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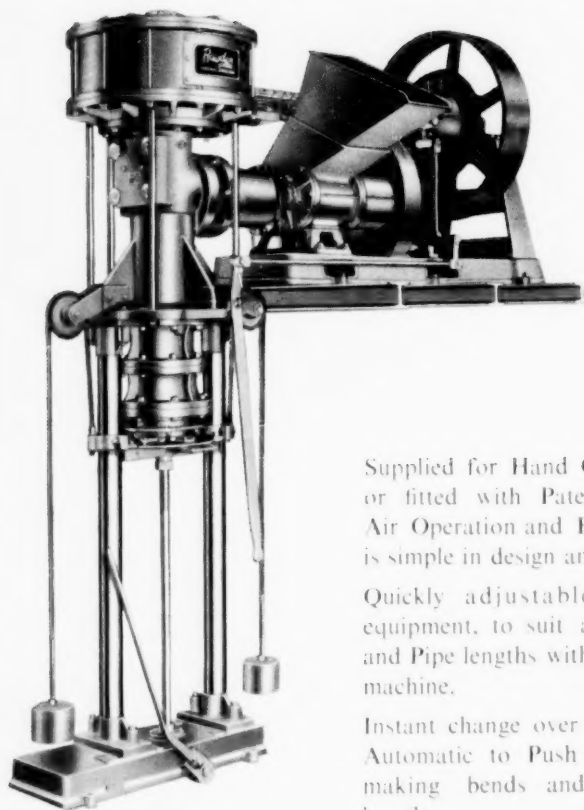
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